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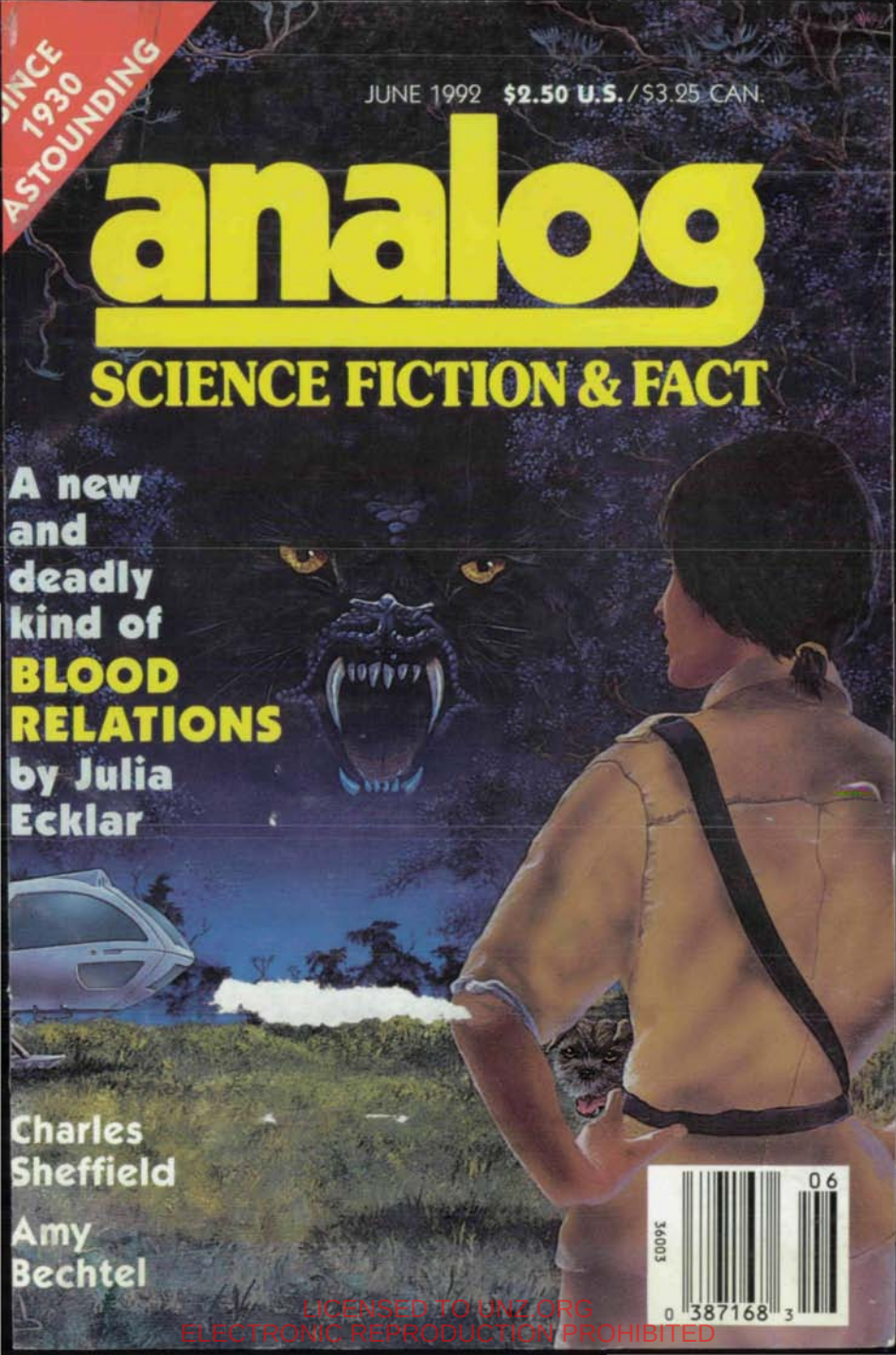

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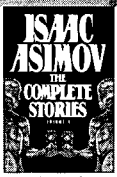

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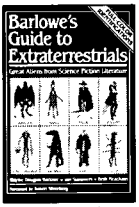

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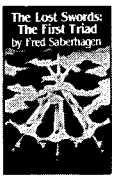

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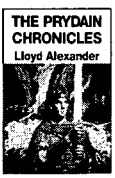

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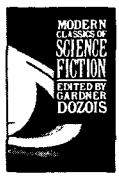

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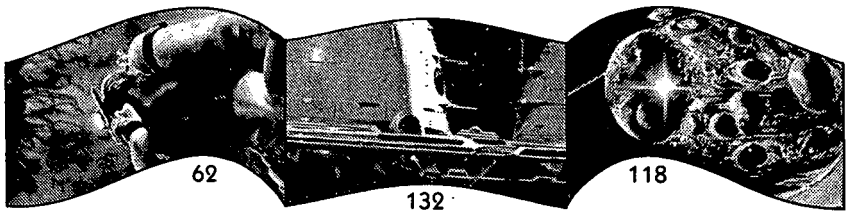

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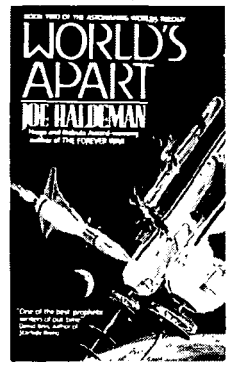

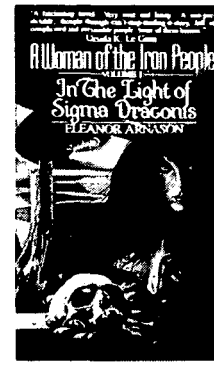

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Editorial

ACCEPT NO SUBSTITUTES

Stanley Schmidt

By now we've had plenty of time to get used to animal rights activists telling us that animal experiments are no longer necessary because anything they can do, computer simulations can do at least as well. Recently I heard a new twist: the idea that not only research experiments, but classroom dissections should be replaced by computer simulations.

Can computer simulations *really* take over all the functions of real animals in biological instruction and research? To some extent, yes. In some situations and in some respects, they may even be better, even from the standpoint of people who feel no fondness, sympathy, or empathy for other animals. Certainly those who do feel such fondness or sympathy would like to find substitutes for as much animal experimentation as possible. But it's naive to believe that computers are going to take over the whole job any time soon. And, ironically, one of the tasks they'll find it hardest to assume is directly related to that matter of empathy.

In research—for example, trying to determine whether a drug has the desired effect and what side effects might come with it—the central problem is that animals are complex and imperfectly understood systems. They cannot, at least yet, be simulated perfectly. (If they could, we wouldn't need either experiments or simulations: we'd already know all the answers!) Simulation may replace *some* testing, but for quite some time to come, the final tests must be on real organisms.

Furthermore, real organisms, even of the same species, are seldom identical. Pharmacology is full of medicines which are effective for most patients but not all. Drugs that have been approved for sale work for most patients without serious side effects, but may give me

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headaches and you nausea. From the doctor's point of view, this means that it's highly desirable to have available a variety of drugs to do any job, and that it may be necessary to try several before finding one that works well for a particular patient. From the researcher's point of view, it means that new drugs must be tested not only on real organisms, but on *lots* of real organisms, to determine individual variations in effect and their statistical importance.

Furthermore, since even a chimpanzee is itself an imperfect simulation of a human, the *final* tests of a human treatment can only be done on humans. Typically, this means volunteers for a while before the drug is approved for sale; but even after that point, the first years or decades of clinical use may still reveal effects not detectable in preliminary tests.

"Animal" testing—i.e., tests on animals other than humans—could easily be eliminated, of course, by going directly to human testing. I doubt that many animal rightists would find that acceptable, though, because the earliest tests of a treatment may turn up large numbers of serious problems. Some treatments don't pan out, and few humans will accept the risk of killing or crippling large numbers of their own kind to find out which treatments do more harm than good.

So if you don't accept human testing in the early stages of research, and you don't accept testing on other animals, that would seem to leave computer simulation. Proponents of this course point to the fact that modern computers are capable of very sophisticated simulations. They are routinely used, for example, to predict the future orbit configurations of things like planetary systems, and have largely replaced wind tunnels in evaluating new aircraft designs. Why can't the same thing be done for biological research?

Because biological systems are *much* more complicated than solar systems or airfoils! In principle, this may seem to mean only that bigger computers and programs are needed. In practice, it means far more than that. A typical planetary system, for most purposes, can be described entirely by one very simple physical law describing a force that acts between pairs of masses. Aerodynamics is more complicated, but for many useful situations the interactions that must be considered are still relatively few and well known. They can be given sufficiently precise and complete mathematical descriptions to make programming reasonably straightforward,

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if laborious. A mouse or a man, on the other hand, involves *so* many interactions, many of them subtle and indirect and not well understood, that it simply can't be adequately simulated with the machines and knowledge we have. To develop a simulation that could really stand in for a mammal, we would need not only more computing power, but more and better information about real mammals to program it with.

And guess what—you can only get that information by studying real mammals!

Yes, if you already know a lot about how a biological system works, you can use a simulation of it to make reasonably confident predictions about how it will react to something new. But the prediction is only as good as the simulation, and the simulation is only as good as the real-world data that went into it. In principle, if you have a complete understanding of how the system works, you can do a simulation that will give perfectly reliable predictions. In practice, you can have that good a simulation only if you've already done a huge amount of experimentation on real systems. To the extent that you haven't, you remain dependent on final tests on real organisms, to turn up any surprises that your imperfect simulations missed.

This is, of course, merely a reflection of the general way science develops. The theories that are most widely accepted in any branch of science at any time are the models which best describe the data accumulated up to that time. Using those models to predict behavior under circumstances not yet examined suggests new experiments. Occasion-

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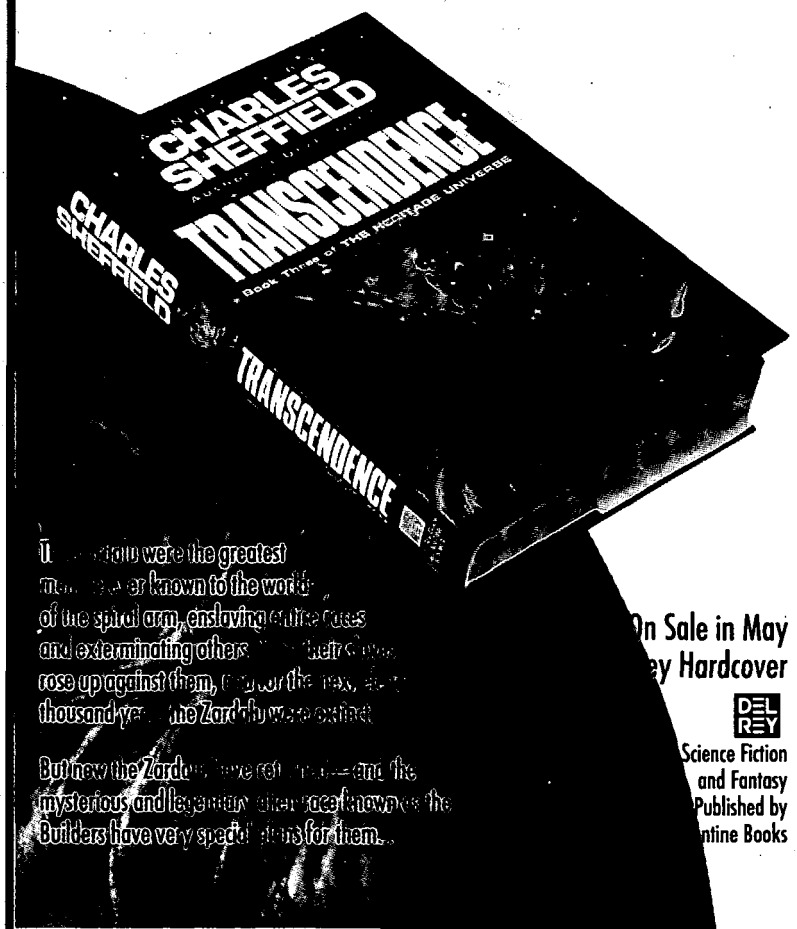

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ally theorists grow stodgy and smug enough to believe (as do the end-animal-experiments folk) that the new experiments needn't actually be done since the results are known from the theory. Real scientists know that theoretical predictions are *not* substitutes for experiment, and the experiments do need to be performed. When their results agree with theoretical predictions, you can be a little more confident that that theory works under a wide range of conditions and you can use it without much danger of unpleasant surprises.

But sometimes surprises do turn up when the experiments are done, and that's when science takes significant steps forward. Relativity and quantum mechanics are well-known and spectacular examples in which a series of experiments gave results so wildly at odds with old theories, that radically new ones had to be constructed from scratch. But sizable surprises can occur even when the old theories are basically sound.

My thesis research, for example, used a physical phenomenon called the Mössbauer effect, which came as just such a surprise to its discoverer, Rudolf L. Mössbauer. As a graduate student, he set out to do what looked like a fairly routine experiment. Nobody had done it before, but well-established theory seemed to say quite clearly what should happen. What really happened was just the opposite, and the explanation didn't even involve any radically new physical principles. It seems there was just a little detail that everybody had overlooked in applying the standard theories to his experiment; recognizing it got Mössbauer a Nobel prize and lots of other people a powerful new research tool.

Those who would put all their medical confidence in computer simulations should keep this possibility constantly in mind. Does this mean that such simulations are of *no* value in medical research? Not at all. Already they can be used for fairly good preliminary testing in some areas, and they'll get better. When they're good enough, they'll even have certain very real advantages over animal subjects for *some* testing. They can give results faster and cheaper, and a sufficiently sophisticated simulation may act more like a human being than a rat or monkey does. A single simulation won't do, of course, since all men and women are *not* created physiologically equal; but there's no intrinsic reason why individual variations can't be reflected in adjustable parameters in a simulation.

My gripe is simply with the extreme position that simulations can or should replace *all* animal experimentation—a view reminiscent of those ancients who sought to achieve perfect understanding through pure reason and disdained to get their hands dirty with experiments on real objects. That position simply won't hold water, for at least two reasons. First, constructing a highly reliable simulation of such a complex system will require not only lots of computer power, but a great deal of data obtained from real experiments. Second, no matter how sophisticated the simulation, there is always *some* possibility of a brand new effect turning up

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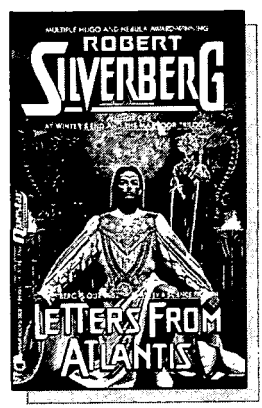

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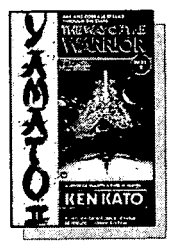

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in practice—so the experiment is never final until it's done on real subjects.

My concern about the proposal to use simulations to replace dissections in school labs is a bit subtler. Yes, they have advantages, aside from the fact that they don't require killing real animals. They are less messy and less dependent on manual dexterity. On the other hand, the computers high schools can afford anytime soon are not likely to do highly sophisticated or realistic simulations; and even if they did, the effect would still be rather like dissecting a cartoon. My fear is that going too completely to this sort of "dissection" would remove that many more children that much further from any gut-level (no pun intended) understanding of the fact that other animals really *are* flesh-and-blood creatures like themselves.

I think it's important that, at least once in his or her life, every human being should actually see and feel the internal structure of at least one other organism, not too distant from our own kind. I think it's important that we *realize* that we're built like that, too, and that when we eat, a fellow organism must die. City kids, all too often, think meat grows magically in supermarket display cases and humans are something quite apart from other animals. Dissecting a frog is probably the closest many of them ever get to understanding how wrong those beliefs are. Losing even that might make them even less aware of how all life on this planet fits together, and contribute, ironically, to even greater environmental irresponsibility.

Maybe, thanks to computer simulations, we won't need as many classroom dissections as we used to—but I'm not convinced we won't need any. And ultimately, research simulations may get good enough to replace *most* medical testing. But that's not a stage we can jump to instantly, and it won't eliminate the need for *final* testing on animals and humans. Nor will it solve the problem of teaching humans about their fundamental kinship with other life forms, and the fundamental ecological truth that for one organism to live, others must die. ■

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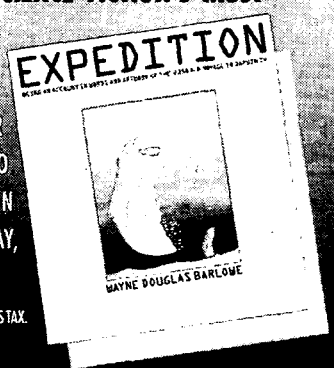

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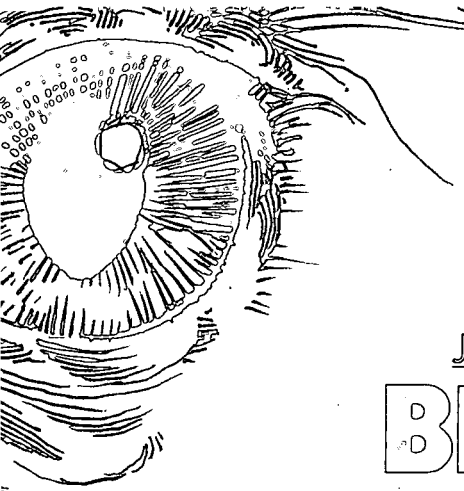
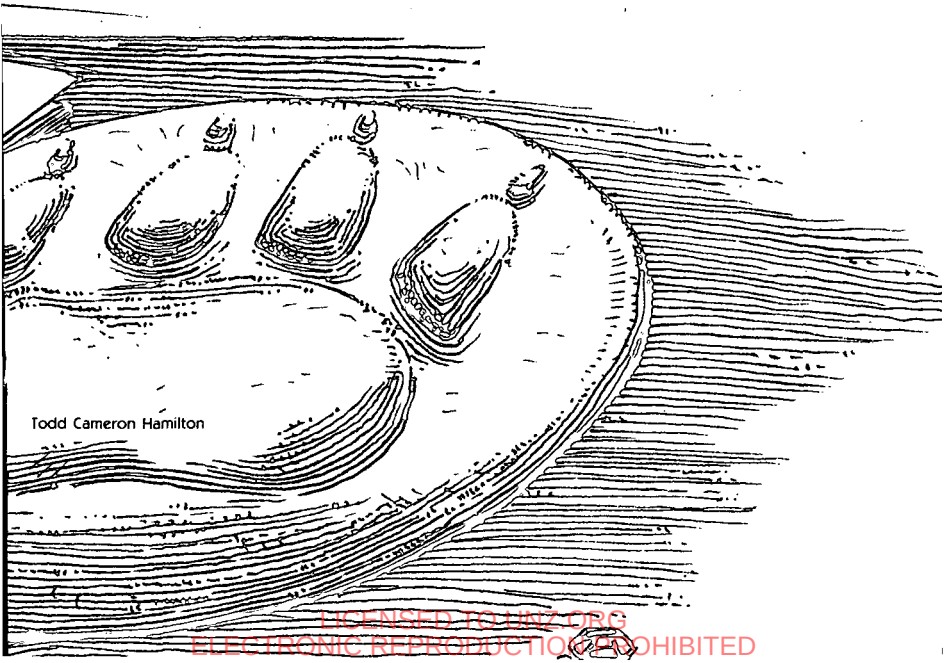


Julia Ecklar

BLOOD RELATIONS

A troubleshooter and the people who hire her don't necessarily define a problem the same way....



Todd Cameron Hamilton

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Basa hated everyone. Rahel always assumed Basa only tolerated her because she let him ride in the lower pocket of her field vest when she pursued native canines across tundras and woodlands. He seemed to like bobbing along, hip-high, with no responsibility except to keep himself from falling out. Black terrier eyes surveyed myriad worlds with malicious interest, and one broken down terrier ear drooped just enough to give Basa an expression of comical confusion. This expression, of course, was a lie. That's why Rahel hated to take Basa around other people; some well-meaning idiot always felt the need to approach the little dog, hand outstretched, and ask:

"Is he friendly?"

Rahel glanced up from the scatter of reports and photos on the table in front of her. A meter away, Colony Prelate Killean Wels waited with his hand suspended just above the terrier's head. Basa, seated half-atop Rahel's work pile, had already started his dance of anticipation, toenails clicking frenziedly on Wels's wooden table top.

"Depends on what you mean by friendly."

Wels seemed to find that amusing. Rahel turned her attention away from his porcelain face and political smile to run long fingers over the plasticast footprints in her hands. Tall and rawboned as she was, she knew what a contrast she must make beside Wels—dark-haired, dark-eyed, even her rough bush suit and vest in various colors of khaki. She was a monochrome person, all drawn in shades of brown, with her straight, jaw-length hair pulled back into a simple ponytail. Compared to Wels's elegantly tousled and braided blond mop, she must look like she had the fashion sense of a farmer. Which, really, she did.

"I mean will he bite me?"

Ah—the persistent type. Rahel shrugged and set the plasticast prints aside. "He hasn't bitten a Colony prelate yet."

The rough, distorted pugs looked as much like tiger tracks as anything else, so Rahel flipped through the reports again while Wels tried to make friendly with her dog. It said here that tigers had been on New Dallas since its colonization fifteen years ago—twenty-three variegated adult Modern Sumatrans, according to the Ark records she'd studied on her way here. The geneticists at Noah's Ark had scrambled the mix enough to make it safe for the tigers to pick their own mates, so—except for a few routine check-ups on the four hundred species of various this-and-that originally seeded on New Dallas—nobody had really spent any time with the tigers before now.

Of course, the tigers hadn't killed anyone before now, either.

Basa exploded into a gravelly avalanche of snarls, and Rahel's paperwork went everywhere as the terrier launched himself across the table at Wels. The prelate swore, jerking his hand back behind him, but didn't erupt into shouting or running away as if in fear of his life. He just stood with his hands held close to him, his cheeks high with color, while Rahel scooped her dog up in one hand and tucked him under her elbow. "Sorry about that," she said automatically, not really sorry at all.

Wels tried on another smile, but it

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faded too quickly. "You said he didn't bite."

"I said he'd never bitten a prelate." Basa hung patiently enough under her arm, but his wiry white-and-black body still trembled with growling. "I guess the other prelates were just faster."

Annoyance tangled Wels's pale eyebrows, but humor toyed with the corners of his mouth. Neither really won out; he finally sighed and crossed his arms in efficient dismissal. "I stand corrected." His fashionably long braids gathered about his shoulders when he dropped into a seat. "So—tell me about our tiger."

His sudden redirection toward business suited Rahel just fine. Shifting Basa to her other arm, she shuffled the reports together with one hand. "Your *alleged* tiger." The stack of flimsies and paper hit center table with a slap. "Is this all the information you have?"

Wels's mouth quirked into that phantom grin again. "I thought you safari types could tell an animal's species, weight, and blood type just by the look of the leaves where the animal passed."

Rahel scowled and rocked back in her own chair. "Then you thought wrong." She hated the sarcastic ones. "Tell me what you know."

"Only what you've got there."

It figured. Pushing Basa to sit on her lap, Rahel basketed her hands around the little dog to keep him from lunging at Wels again. "Well, all you've got here is a list of who was killed, where, and when. You give names and addresses, who they lived with, when they were last seen, how long you figure they were dead before your Cop Shop found their bodies. You've got pictures, the one good plasticast, and a bunch of speculation from a lot of local yokels who seem to have picked on the tigers 'cause they were the biggest thing around." She wished they were outside, where there might be something nearby to throw. "Even us 'safari types' can't get jack-shit out of that."

Wels toyed with one earring and stared at the pile, but Rahel could see the line of his jaw bunch and move while he chewed over what he should say. She wondered if these "Colony types" knew that safaris would end a lot faster if colonists would just spit up what they knew and get out of the way.

"I gathered whatever information I could think of," Wels said finally, slowly. "We haven't had to call Noah's Ark back to New Dallas since the animals were originally seeded here. I didn't know what kind of information you'd want."

Honest, at least, if stupid. She sighed and tried to keep her voice neutral. "I want a lot of stuff you probably can't tell me. But let's start with why you're so sure it was a tiger that killed those people."

Wels laced his hands in his lap and squared his shoulders, as if planning to carry some heavy load for a long way. "There have always been tigers in Melissa Pass. They showed up sometimes on our bioscans, and my miners reported seeing them now and then. But we were set up fifty kilometers outside the Pass, so the tigers never got anywhere near our outposts. But there was once . . ." He shifted a little in his seat, and embarrassment made his eyes glisten. "One of the fellows got drunk while they were surveying the Pass a

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few months ago," he explained awkwardly. "He got drunk with one of the cops and a couple of the other miners, and they all ran around in the brush 'big game hunting.' " His eyes glanced away from her to the paper pile again. "They shot one of the tigers."

Her ears rang with a surge of anger, and familiar self-hatred snarled up inside her until she wanted to kick the prelate's office to pieces. Frustrating—so goddamned frustrating to try and uphold anything fair and right when all it took was one thoughtless primate to shatter anything she and the others could do. "You signed an agreement with Noah's Ark," was all she could make herself say—and that not even politely. "You can lose your Colony Charter for killing even one protected animal."

"I know that." His hand drifted up to play with that earring again. "They only managed to wound it, and I fired all of them and shipped them off-planet immediately. Everyone else understands that nothing like that is to happen again. We've had no further incidents."

God, she wanted to backhand the look of contrition off his face. In her lap, Basa grumbled and circled three times before lying down. "You still should have reported it."

He snapped a brave look into her face. "I didn't want to lose my Charter. Not over one wounded animal."

But you want to break contract with Noah's Ark over a couple of dead people. Rahel traced the soft inside of Basa's ear, listening to the tiny, ticktock growl that meant something pleased him. "So what has all this got to do with your killings?" *Stick to business,* she chastised herself. *You'll never get to leave if you don't solve their problem.*

"Those tracks look pretty scarred up." Wels pointed at the plasticasts in front of her. "We got those at Melissa Pass, where I sent a man just two weeks ago to scout out a new vein. When the follow-up crew arrived four days later, he was dead. We thought maybe it was the tiger who'd been injured before, that maybe it couldn't hunt like normal anymore. That—" the prelate cleared his throat with some embarrassment, but went on, "—that maybe it hated people."

Rahel snorted. The only thing worse than a human who had no respect for other animals, was a human who believed all other animals thought and felt just like he did.

She glanced down at her notebook to check on Wels's facts. The surveyor would be Del Harbin, age forty-seven. They estimated he'd been dead since shortly after reaching Melissa Pass —between tiger damage, decay, and the amount stolen away by scavangers, they'd only been able to identify him via DNA. "It says here there were other deaths," Rahel said. "What happened to them?"

"Pretty much the same. A couple days after I left the miners alone in the outpost, they 'linked us to say one of them had been killed—apparently by tigers." His gaze dropped to his hands, and he rubbed at one thumbnail as if trying to scrape something away. "By the time I got a flyer out there to pick them up," he went on, very steadily, "the other two were dead as well."

Somewhat against her will, Rahel felt

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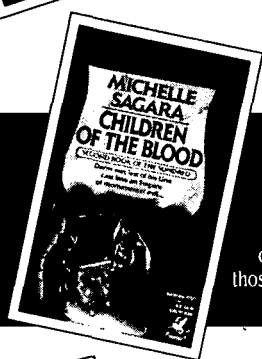

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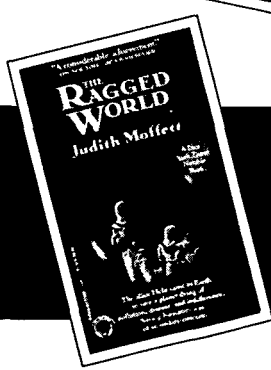

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a sting of sympathy as she tried to imagine that little surprise. She pushed the feeling away. "How well did your people clean up the attack sites?"

"Pretty thoroughly," Wels admitted with a sigh.

Rahel ground her teeth. "Well, what about during the autopsies? Did anyone run a protein match on the bodies? Any leftover tiger biology should stand out dandy on a human corpse."

Wels continued staring at his fingernails.

The prelate's guilty silence burned on the air. "Hair?" Rahel persisted. "Didn't you even think to collect hair samples? Or photograph bite signatures?"

When Wels finally looked up, it was at some vague distraction to his left, not at her. "We didn't perform autopsies."

Didn't perform autopsies. Without any data, they just expected her to come in and wave her magic wand to solve the problem. "You didn't perform autopsies," she guessed, "because you already knew the killer was a tiger."

Wels at least had the grace to nod miserably.

To channel off some of her frustration, she wrapped her hand around Basa's whole head and shook it gently, fondly. The terrier sighed and thumped his stumpy tail. Seeing him happy soothed her into a tiny smile. "The problem," she said to Wels at last, "is that we still don't know *which* tiger. Assuming my investigation even agrees with your tiger hypothesis."

She bobbed forward just far enough to snag the pile of reports and pull them back in front of her. "As an employee of Noah's Ark, it's my duty to figure out which Ark-bred animal is causing your difficulty, and why. Then I can use my discretion—" she cocked a nod toward Wels, "—and your suggestions—" That was the most deference she was willing to grant him. "—in deciding how best to rectify your situation. I think I should warn you, though, I'll opt for relocation of the animal over killing it. If you can't live with that, get yourself a new proctor now."

Wels studied her for a long while, lips pursed, brow knit. Just when she'd decided not to wait around for his answer, the prelate announced, "I just want the killings to stop. Any solution that promises my miners' safety, I can live with."

Rahel nodded; that was one less fight, then. "Consider this contract in action." She slid one hand under Basa and got to her feet. Basa growled and snapped at the paperwork as she shoveled it up with her other hand. The plasticast footprints disappeared into Basa's favorite riding pocket; he'd have to rough it back to their quarters. "Come morning, I want to sniff around the Melissa Pass mining outpost. I've got my own equipment—all I'll need from your AI is directions."

Wels stood with her, obviously caught somewhat off guard. "Do you think it's safe for you to be up there alone?"

"I guess we'll find out, won't we?" Rahel stepped around him to head for the door; Basa snapped at him, as well, in passing.

"I'd really rather you take someone with you," Wels insisted, staying close behind her.

Rahel paused in the door, holding it

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open so the unprocessed smell of outside could wash over her while they talked. "Have you got robots?" she asked without turning around. "I don't even care if they're Newborn—just plain robots are fine."

Wels was silent for a moment. "No. Just human colonists. But I'm sure someone—"

"Forget it." She stepped all the way outside, and the bright midday sunlight hurt her eyes. "I'd rather go alone."

"Ms. Tovin, I already have plenty of proof that tigers are dangerous without you getting killed, too." Wels caught the door before it closed, his hand stopping the sculpted metal with a soft slap. "Do you really trust animals that much?"

"No. I hate people that much." Rahel produced a thin smile, and half-turned so he could see her expression for the truth. "See you when this is all over, Prelate."

She left him still standing in the doorway, the shadows of a tree painting tiger stripes across his eyes.

Melissa Pass smothered under a calico blanket of treetops and mist. Looked like tiger country to Rahel, for all that was worth. She pushed Basa off her lap and down-throttled the pachyderm to glide the ship under the gnarled foliage. Tall, heat-brittle grasses bowed aside at the pachyderm's passage, and a herd of native jembels bounded out of sight as she flew by, the flashes of their frantic white tails the only remnant of their disappearing act.

A glimpse of glossy, slate-colored rocks spoke of a spring or pool less than three kilometers from New Dallas's mining outpost. Tigers liked water. Rahel thought back over all the studying she'd crammed into the night before, trying to remember what (if anything) she'd learned about territories, den sites, and numbers. All she could remember was that tigers almost never killed people and always lived alone.

Frustration forced a groan from her, and she put her hand down where Basa could chew on her fingertips. She was not the best choice Noah's Ark could have made for this safari, and she knew it. Saiah Innis—perhaps the Ark's wisest jungle feline specialist—had supervised the original seeding of the New Dallas tigers; he was twice Rahel's age, but still had to be a better proctor than an irritated canine psychologist who hadn't looked at tiger spins since school. When she bitched about this last night to her supervisor, though, he told her, "You were closer, Rahel. Don't worry—you'll do fine."

Easy for him to say. He got to stay on Eden.

Which was where Rahel would rather be right now. Not that she didn't trust the journeymen proctors assigned to replace her, she just believed in instincts above and beyond what a proctor learned from schools and tapes. That sense grew out of innate talent and experience—neither of which she had for Sumatran tigers. Saiah Innis would have smelled the solution to this safari fifteen minutes after bumping port; Rahel Tovin had a feeling she wasn't going to smell anything until she stepped in it. A string of murdered people and murdered tigers might solve the problem as far as Killean Wels was concerned, but it wasn't the solution Rahel hoped to

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settle for.

The Melissa Pass outpost bubbled up from the jungle floor like a blanket of bulbous white mushrooms. The place must have stood out like a diner's club, even to a color-blind tiger. Any tiger dining on humans in the first place was undoubtedly either sick or injured, making humans the only prey too slow and stupid to avoid it. Rahel had to admit—if her only choice was between stalking an outpost and starving, she'd probably opt for munching miners, too.

Circling the outpost on low-throttle, she activated the pachyderm's chameleon to mask the transport's sight and smell, and set down as close as she could to the outpost's wide open hatch. Basa twirled about the floor in an orgy of excitement.

Rahel kept trotting back to check the open hatch between sorting together sample slides and testing gear. Oh, these miners were pips, all right—too weak-kneed with their phantom tigers to even think about dogging the hatches behind them when they abandoned the post. They might not be able to hard-lock them from the outside to prevent human entry, but they could at least latch-lock them and keep animals out. Who knew what sort of things had moved into the premises in the week since? On top of further corrupting an already ruined attack site, such second-hand renters also meant Rahel couldn't feel safe inside the compound without a couple of extra pairs of eyes.

She toed Basa away from the pachyderm's hatch, ignoring the terrier's attack on her boot. "Back. Back!" He minced back from the hatch by four precise steps, grumbling doggy complaints. "Sorry, Basa—you've gotta stay here. Don't want the big, bad tigers to eat you." She slipped a snooze pistol out of the cabinet and squeezed out the hatch while Basa pouted. "I'll let you know when I've decided all's clear."

A mantle of jungle heat pressed against her as she darted across the distance between pachyderm and outpost. She slowed at the doorway, checking the snooze pistol's charge and purposely slowing her breathing. Soft-soled boots shushed breathlessly against the flooring as she crept inside.

The interior wasn't nearly so humid and foul-smelling as she expected. Work surfaces sat neat and undisturbed; chairs and lounges still possessed all their stuffing; a faint, brittle scent of industral cleaning chemicals hung like spider's silk on the air. She didn't know how the place got open now, but she'd just about decided it must have been locked all week when she edged around the last open hatchway to find Wels waiting patiently inside.

Her fingers twitched on the handle of the snooze gun, and she jerked the muzzle toward the ceiling by reflex, just in case it went off. It didn't, and even that irritated her. "I ought to shoot you," she told the prelate.

Wels seemed remarkably unperturbed by the threat. "I thought proctors didn't carry guns."

"You think a lot of things that aren't true." She abandoned him long enough to trot back to the entrance and dog the outer hatch. Stupid of him to leave it hanging open when he didn't even have a gun of his own; he couldn't guess what might wander in here any more than she could, and he was a lot less likely to

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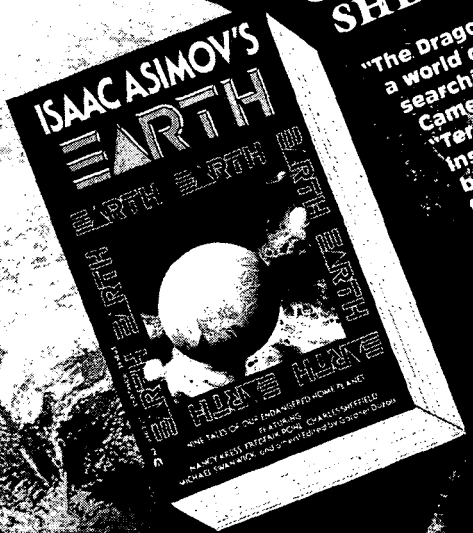

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know how to deal with it. When she got back to him, he still waited patiently, both hands folded in the lap of his neat, new-bought bush suit. She felt remarkably earthy and competent by comparison.

Wels made a show of leaning over to peer around her. "Where's your rabid side-kick? Do I have to get ready to run?"

"I left him in the pachyderm." Shoving the snooze pistol into her trouser pocket, she demanded tartly, "What are you doing here?"

He straightened and shook back his elaborately braided and bound blond hair. "Waiting for you."

Rahel snorted, wishing she'd brought Basa in after all. "I already told you—I don't want your help."

"Oh, I don't intend to help. I intend to observe."

As if his presence would somehow prove too beneficial for her to resist. "Great." Rahel swung her pack onto the nearest work desk; it landed with a satisfying *clunk*. "Just fucking great."

Wels's mouth drew tight with annoyance, but Rahel gave him credit when he didn't fidget or twitch. "This Colony is my responsibility, Ms. Tovin," he told her in a flat and reasonable tone. "The people who live and work here expect me to take care of things so they don't have to. I'm not about to sit twiddling my thumbs at Colony Central while you do whatever it is you do out here. I want to know what's going on."

Rahel dumped a handful of sample slides onto the table. "Like you're going to understand everything just because you see it."

"You can explain it to me."

"Yeah, sure. That'll make things go *so* much faster." She turned with her hands full of sampling gear, and sighed. "You're just going to get in my way."

Wels stood, poised on his toes as if ready to leap in any direction she chose. "I'll try not to." He flashed his faint, cutting grin. "What's first?"

Kicking him back to Colony Central was a now or never thing, Rahel knew. Assuming, of course, he didn't just run back out here to harass her some more. Sighing, she decided she'd rather take control of both the situation and him right now. "All right, then. Let's get started." She sorted her slides into order and stepped toward the center of the room, already suspecting she'd regret her capitulation. "First, I scour the attack sites to see if your people left me enough in the way of samples to do me any good." She flipped through the screens on her notebook. "Says here two of the attacks occurred outside the outpost." She glanced a question at him over the screen.

Wels nodded. "The very first one—the surveyor who was alone, Del Harbin. We airlifted his body out when we dropped off the start-up team, then shipped his remains homeward." Rahel added one more last data set to her tally. "The first casualty among the start-up crew was also killed outside," Wels went on. "They kept her body in the infirmary awaiting pick-up. We, uh . . ." He crossed his arms suddenly, and cleared his throat. "We found her still there when we came to lift them out."

So Wels had been with the group who cleaned the outpost. No wonder he wanted this tiger thing solved so badly.

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Bending her attention to the notebook again, she asked, "So the other two were killed inside?"

He nodded, pointing toward the center of the room. "There, and there. We found them here with the outside door still open."

She grinned with amused disgust. "And you left the same door hanging open while you waited for me? Brilliant."

"I only just opened it when the outpost system said you'd arrived," Wels bristled, pulling his chin higher. "I'm not that stupid."

They'd have to see about that. "How many hours have we got 'til planetary dark?"

The apparent change of topic caught Wels unprepared. He blinked in confusion, and brought his arms back to his sides. "Four or five. Why?"

"I want to check the outside sites first. They're probably next-to-useless, but I'd rather know that than guess." She paused to glance over her surroundings. It struck her for the first time that this must be a rec room, small though it was. She wondered if the miners had fought the tiger at all, and if the furniture might retain blood stains or saliva.

"If you show me how," Wels interrupted her thoughts, "I can collect some samples in here. Just until you get back from outside."

Rahel made a face at him. "You told me you'd stay out of my way."

The expression on Wels's patrician features was too ingenuous to be sincere. Rahel wanted to smack him. "I won't be in your way—I'll be in here while you're outside. And I'll stop as soon as you get back, I promise."

Save the time, she told herself. *It's not like there's anything in here for him to find anyway*. Motioning for him to join her, she moved toward the segment of floor scarred up by the colonists' zealous cleaning.

"I still need an ID on this tiger," she explained. "The more data I can get from each of the attack sites, the better chance I'll have to crapping together a DNA model. Especially since you guys didn't leave me much to work with." She crouched at the edge of the scarring; Wels squatted beside her. "If this is where the killings took place, there must have been a lot of blood spread around here. We'll take some samples from here, just in case there's enough left to compare against the slides we pull elsewhere."

Wels pressed his hands to the floor between his knees. "How will we know that the . . . blood and things we get here aren't . . ." Taking a huge breath, he rushed on ahead. "That they aren't from my miners?"

Rahel shrugged, counting her slides. "Do you still have any of those bodies at New Dallas?"

"I'm afraid not." Wels's very tone was apologetic. "We shipped them back to their homeworlds as soon as we were able."

"Shit."

"Sorry . . ."

Rahel waved his apology aside; they'd already wasted too much time just determining that they didn't really know anything. "Doesn't matter. We'll just have to use their medical records, is all." Would have been nice to have the fresh comparison, though.

Taking his hand, Rahel turned it palm

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up and spilled several slides into it. "I need samples from all over this area—the floor, the furniture, anyplace you think the tiger might have touched. If we still had those bodies, I'd check their skin and clothing, too, but there's nothing to be done for that."

Wels obviously checked himself from apologizing again. "What are we looking for?" he asked, stacking the slides together.

Rahel peered at him sidelong. "*I'm* looking for biological traces of our alleged tiger. Saliva, blood, skin. Saliva and blood would be best, since they'd also tell me if we've got a sick tiger on our hands." Not that she really expected to find usable samples of either. Didn't hurt to try, though. "Here—this is how you get a sample."

Wels didn't interrupt her throughout the quick lesson, and he caught on easily enough. She counted out five sets of ten slides each into his hands, then pushed to her feet to collect her own gear. "You can't get into the pachyderm without me, so just wait here 'til I get back."

"I wouldn't want to try and get past that attack beast of yours anyway," Wels assured her, smiling.

Rahel swung her pack over one shoulder, not smiling in return. "With that in mind, do yourself a big favor—keep the outside door hard-locked from the inside while I'm gone." Much as she would have liked to have samples from a fresh tiger kill, she didn't think Colony Central would approve of how she got them.

Rahel imagined she could hear Basa wailing while she felt her way around the camouflaged pachyderm. Interior sound couldn't travel outside, she knew, and she'd never had any proof that Basa either barked or howled in protest to her absence. He sometimes tore up her belongings something fierce, though, and had once peed all over whatever of her clothes he could find. So it seemed likely he bitched aloud at her heartless abandonment. She considered it a blessing that she was usually able to take him along when she hiked, otherwise she could never have afforded to keep him.

Not today, though. Not when Wels and his yahoos had left so little physical evidence for her to recover at any given site. Basa's very presence could drop enough dander and hair to corrupt a site beyond using; hell, her own presence probably ran that risk as well. At least she was fairly certain she could identify her own head hairs without having to run them through the sequencer. She didn't want to depend on that with Basa's.

As she stepped beyond the pachyderm, air as warm and gamy as a carnivore's breath frumped with her clothing and feathered her hair. It felt good for the briefest moment—lifting away itchy, ever-present sweat—then the jungle seemed to run out of breath and left her in sweltering stillness again.

Not that the jungle was ever truly silent or still. Rahel flipped her notebook open to the Cop Shop's description of Harbin's murder site, following those directions with one eye while slipping between foliage into the deeper darkness beyond. Her senses expanded without her having to think about it, listening for the scratch and chatter of

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every leaf; watching for any movement not explained away by sunlight, shadow or breeze; sniffing the air for the tell-tale spike of musk or urine that sometimes meant a large predator nearby. The bioscan on her wrist could tell her much the same things, but, for some reason, she resented trusting equipment for information she felt her instincts should be able to deliver; not feeling and not seeing didn't necessarily mean not there. She knew that, and she suspected the tigers did, too.

She wondered if Harbin had been wearing a bioscan.

Her notebook beeped when she reached the murder site. Stopping, she confirmed the location with a quick look around and grumbled (much like Basa) to herself. The week had done its work; a cairn of soggy leaves marked where the tiger had probably tried to conceal Harbin's body for later eating, and a burned-yellow patch at the base of a tree hinted that territorial spraying had dripped down the trunk to the ground. Rahel fished three clean sample slides from her vest pocket and moved to kneel beside the urine-stained tree.

The smell of ammonia prickled faintly at her nose, sunk too deeply into the bark to tell if it were fresh or long-standing. Wiping three samples from various stinking areas, she promised herself she'd collect more if time and light allowed. The slides clicked together in her pockets as she shuffled on hands and knees around the edge of the site.

Drag lines, trampled sticks, splayed and scarred up tiger pugs. She sniffed the ground at the clearest print, drinking in the thick, living smell. But it smelled of hot earth, nothing more, so she moved on. Eventually, she wrestled the magnification gear out of her pack and let it scan the ground ahead of her, showing her sand grains as big as finger bones, beetles as large as birds. She found a blade of grass with blood on it (probably Harbin's), and a single long, lovely whisker lying white against the ground. All the over-large sample slides had been left in the pachyderm, but the beauty of a whisker was that it wouldn't lose its informative value by being introduced to pocket lint. Thumbing open a tiny breast pocket, Rahel slipped the single whisker inside and patted her treasure proudly.

A wicked sting raced suddenly along her radial nerve, making her hand twitch against the air. Adrenaline pounded into every fiber, and she clutched at the bioscan on her wrist to silence it; a ghost memory of the warning still made her fingers tingle. Around her, colors had deepened like wet cloth, dusted over with shadow by evening's approach. She lifted slowly to her feet, probing the jungle with eyes, ears, and nose for any sign of the big life-form detected by the scan. She felt as though her attention might cut her, it had suddenly narrowed so pointed and sharp.

But, of course, she heard, smelt, and saw nothing—the bioscan picked up on life-forms at a far greater distance than she could possibly be expected to sense. Slipping the snooze pistol from her pocket all the same, Rahel crouched very slowly to retrieve the last of her gear, all the while darting her eyes among the foliage and the shadows.

"If you're out there," she whispered to no one but herself, "I'll find you."

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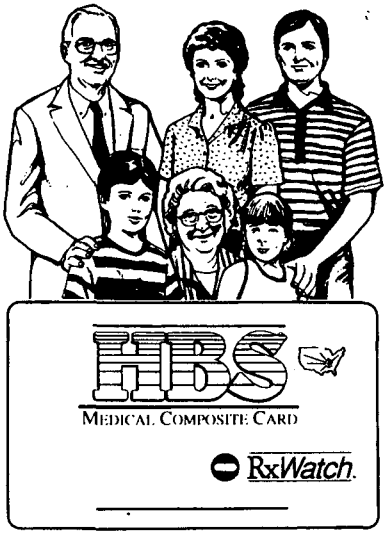

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The tiger didn't have to answer. She had a piece of it, intact and in toto. That would tell her everything she needed to know.

Basa greeted her inside the pachyderm's hatch, wheeling and prancing and whining with desperate delight. "Back!" He skittered dutifully away from the hatch, and Rahel scooped him up without slowing, bouncing him from hand-to-hand as she picked her way through the minor destruction he'd wrought on her dirty clothes. It seemed he could ferret out her laundry no matter what she did to stow it. "You've been a bad bud," she said without conviction. Basa apologized for his behavior by gnawing on her pocket flap.

The testing station AI came up without greeting her (Rahel had disabled that annoying little courtesy years ago), and accepted her slides and notes without comment. When the last sample was logged and labeled, Rahel cleared the unused slides from her pockets to make room for Basa. "I need a DNA map and search," she told that station. "Reference: Sumatran tiger, Saiah Innis." Basa slipped into his accustomed pocket with much squirming and sighs. "Primary match code: Genetic set #8737, New Dallas subset. Secondary code: Likely genetic combinations of #8737 descendants. Give me sex and age."

"OK."

"If any results come up with human DNA, disregard them."

"OK." It shuffled both samples and parameters with a string of muffled clicking. "I can have results for you in approximately nine hours thirty-seven minutes."

Rahel glanced over the bioscans and kicked her scattered clothes into a pile. Nothing had come near the pachyderm except a string of confused birds and something ankle-high that waddled. "It takes as long as it takes. Knock yourself out."

"OK."

"And file those samples for reference when you're done."

"OK."

Darkness had clogged the jungle quickly since Rahel ducked inside. Sealing the pachyderm behind her, she waited in the recessed hatchway until her eyes adjusted to the dim. A tapestry of insect songs and night wings repainted the jungle in colors of sound, showing her the path from pachyderm to outpost as clearly as any light could. Even the air that hugged her face like warm wings smelled of a new and different life than graced this world in the daytime. Rahel breathed in these secret stories and let them swell her spirit. Sometimes, when the workings of nature pressed in so close around her that she could stand at their edge and almost feel like she belonged, Rahel could believe humanity still had some useful place in it all. Besides scrambling to repair its old mistakes, that is.

She punched up the latch-lock at the outpost door, and pulled a severe frown when the hatch slid obligingly aside. That little dance of technology combined with the stark, white interior to sever her connection with her fleeting native peace. All over again, Rahel's stomach burned with a hatred of all things human, and Basa picked up on her rage just enough to growl at Wels when they found him in the rec room.

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The prelate, seated on the edge of one of the empty work desks, jerked his head up at the sound. A cool, cynical smile quirked his lips, but honest fear flashed across his eyes as he asked, "Is it safe to be in the same room with him?" He aimed a slim finger at Basa.

Rahel shrugged, tugging at the dog's flopped-over ear. "Probably not." *It wouldn't be if I was him.* "Didn't I tell you to hard-lock that door?"

Wels shrugged, unconcerned. "Tigers can't work latches, Ms. Tovin. I figured it was safe enough just closing them."

"Tell that to your miners." She motioned him impatiently toward her. "So what did you do in here besides pick your nose while I was gone?"

"I didn't pick my nose." Wels slid off the desk top, the pockets of his trendy bush suit clinking with slides. "I figured that would contaminate your samples." He fished a handful of slides from each pocket and held them out to her, smiling. "Not that I found too many. I think the ones I found are good."

Rahel snorted, but kept Basa pinned with her elbow when she reached for the slides. Squirming his butt deeper into the pocket, Basa grunted with disappointment at not being allowed to make a lunge for Wels's fingers. Rahel understood his frustration.

No matter how many he'd tried to collect, only four of the slides actually listed samples retrieved. She figured that was expected, since Wels even admitted they'd cleaned up the post before leaving with the bodies. The first slide was supposed to be a blood scraping (probably useless), two others didn't look like much of anything (almost definitely useless), but the last, wonder of wonders, contained a single ebony hair.

Rahel raised one eyebrow and peered at Wels over the slide. "You're not shitting me? You really found this?"

The prelate shoved his hands into his pockets, pursing his lips in prim annoyance. "I really found it. On the floor. Over there." He pointed at a corner behind him without turning.

"It's not one of your eyelashes?"

"My eyelashes are blond."

His face had flushed coral pink at the suggestion, his annoyance quickly supplanted by good old-fashioned anger. He reminded Rahel of Basa when she took away anything he was particularly intent upon mauling. She couldn't help grinning while she pocketed the slides.

"Then pat yourself on your downy little head." She tossed Basa a couple of times, enjoying both the dog's happy grunts and Wels's accompanying frown. "If your slides match the ones I got outside, we've got a positive ID on your attacker. Which means we get to go out tomorrow with a nice nucleic acid sequence and a tag signal to keep us company."

Wels didn't follow right away when she turned for the front entrance. "Where are we going tomorrow?"

"Into the jungle." Rahel opened the hatch with one hand, not even pausing to let her eyes adjust to the dark before striding away from him into the open. "Hunting scat."

Wels had to jog as far as the doorway, then, to call after her, "What's scat?"

"Tiger shit. You're going to love it."

* * *

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Rahel plugged Wels's slides into the testing station under the same parameters she'd used on her own. The AI promised to spit up some results by mid-morning tomorrow, latest. A little later than Rahel had hoped for, but the best it could do. "We can let our Colony kid sleep in."

"OK."

When Wels finally made the short jaunt between outpost and pachyderm. Rahel let him make up a bed for himself in the cockpit while she promised to keep Basa in back with herself. Then she keyed the pachyderm's interior to reflect the jungle setting outside, just so she could feel like she was sleeping with nature even though the thickness of machine walls stood between them.

Laying on her side, staring into the foliage, she pushed Basa onto his tummy near her waist when he wouldn't settle down on his own. Slick, black fronds swayed outside the pachyderm's walls, and Rahel couldn't see what moved them. Bright, tiny eyes glittered beneath the underbrush, only to blink once or twice, then vanish. Once, an invisible flock of day birds exploded into shrieking when something deeper in the jungle disturbed their sleep. Even Rahel's dreams that night were fractured by the sound of distant, coughing roars.

Three or four times before morning, Basa woke her by dancing on her stomach and growling at things he could see beyond the walls. Whenever she rolled over to look, though, she never saw anything there.

FILE #834287

RESULTS: MATCH TEST 1

RAHEL TOVIN, PROCTOR: NEW DALLAS SAFARI 7

SLIDES 1418-1424

REFERENCE: SUMATRAN TIGER [*Panthera tigris*], SAIAH INNIS

* * * * * * *

GENETIC SET #8737, NEW DALLAS SUBSET: SEE "DESCENDENT #8737"

DESCENDENT #8737: 99.9% CONFIDENCE

SUBJECT #55, "ARJUNA," MALE, 4 STAND YRS: 98.899% CONFIDENCE

(SUBJECT #55 TAGGED BY SAFARI 6, DAY 9. SEE RECORDS FOR SAFARI 6 FOR FURTHER INFORMATION)

Rahel switched functions on her notebook, checking Arjuna's tag signal against their coordinate map while she waited by the outpost hatch for Wels. The tiger was apparently still stationary at less than four kilometers away. That unnatural stillness intrigued her, made her ready to be up and on their way. Wels's lateness, then, only made her want to cut off into the jungle and leave him to find his way out on his own.

Through the outpost door behind her, Basa protested his confinement with intermittent attacks on the hatch. The skitter scramble of his toenails carried to her almost as clearly as his wails. Rahel kicked back against the door in hopes the sudden boom would startle him into silence.

"Back!" she called over her shoulder when that tactic didn't work. "It's your own fault you're in there." She didn't dare leave the terrier alone in the pachyderm, not with Wels's gear scattered all over the vehicle with her own. If Basa mauled and ruined her own things out of love, she could just imagine what

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he'd do to Wels's. She couldn't say she blamed him, though. "Wee-wee your little heart out, bud. There's nothing in there I care about."

"I hope you're not talking to me." Wels appeared in a doorway that seemingly stood in midair. The pachyderm's open hatch was the only section of the vehicle currently unable to reflect the jungle surroundings.

Rahel snorted and hefted her pack to her shoulder. "You can wee-wee your heart out, too, if you want. It'll probably attract the tigers." She motioned irritably for him to step down. "Get out of there and let me dog the hatch so it doesn't look like such a goddammed window."

Wels scooted obediently to one side, then stood and plaited his hair into a cap while she sealed up the door behind him. "The outside of this thing makes me feel so antsy. You've got it fit with a repulsor, don't you?"

"Yep." She turned to push past him, ready to be on her way. "It irritates most animals enough to keep them away. That way, the little birdies don't bash their little pea brains out while I've got the chameleon on. Too bad it doesn't work on Colony prelates."

Wels smiled in appreciation, then fell in step beside her. "So what with the repulsor and the chameleon, are we actually going to be able to find this thing when we get back?"

"Sure." Rahel checked Arjuna's signal again without slowing or looking behind. The pachyderm might be invisible to Wels—and maybe even to the thousands of color-blind animal eyes that overlooked it every day—but Rahel had long ago adapted to spotting it in all sorts of terrain. Like the photocells' reptilian namesake, the chameleoned pachyderm stood out against its surroundings like a silhouette cut from same-colored cloth—matching in pattern, but easy enough to spot. She focused her attention instead on the static tag signal on her notebook, frowning.

Wels matched her pace easily enough, studying the jungle all around them with interested eyes. He didn't need a testing pack, but Rahel had consented to letting him carry a charged snooze pistol, just in case he proved too stupid to graft himself to her hip. So far, he kept obediently within range, sometimes bumping shoulders with her when the rhythm of their movements fell out of sync. That unasked for contact nettled her more than if he'd just run off into the trees and gotten killed. Rahel wondered if the Ark would pull her off this safari for snoozing Wels and locking him in the pachyderm with Basa. She got to spend three uninterrupted years in research after doing that on Resus. It might be worth an encore now.

"So." Wels broke into her thoughts with an idle, make-talk sigh. For all that his hands stayed in his pockets, he seemed alert enough, and watchful. "Are we really out here looking for tiger droppings?"

"Tiger droppings." Like it was something they did by accident while trying to get from one place to the next. "Well, with such nice results off my slides, and yours yet to confirm them, we don't really need scat anymore." Rahel glanced at the tiger's signal again. "If you see any, though, you can always let me know." Christ—not even

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ten meters away.

"I don't know what tiger scat looks like."

"Then it's pretty pointless to ask about it, isn't it?"

A flush of brief anger brightened Wels's eyes. He pursed his lips around it, sighed. "I'm doing everything in my power to cooperate with you—I haven't even poisoned your lovely little dog, much as I've been tempted. You don't need to go out of your way to aggravate me."

Rahel fished her snooze pistol out of her pocket, trying to believe the twitching in her stomach was because she knew they were close to their killer and not because Wels's insight into her behavior bothered her. "You don't even know me." She slowed to a stop, her voice dropping to a near-whisper. "Don't tell me what I do or don't need to do."

When he took breath to argue further, she clapped a hand over his mouth to silence him. Wels's eyes narrowed, and Rahel felt his lips pull tight against her palm. Leaning close to breathe in his ear, she whispered, "Time to shut up and climb a tree."

Blue eyes widened beautifully, and slim fingers wrapped around her wrist to pry her hand away. "Where is it?" Wels mouthed.

Rahel nodded over her shoulder, deeper into the brush. It was nice to see him speechless for a change. She decided not to tell him that Arjuna's signal hadn't moved all morning, or that her bioscan didn't flutter even now. She already had a good idea what that meant, but didn't want to spoil the moment. "Get in my way now, Prelate," she said, checking the charge on her pistol, "and I'm perfectly willing to let him eat you. Nature's way, and all that. Got it?"

He scowled and stepped away to put his back against a tree. "Got it." Knuckles white, he slipped his own gun from his pocket and clenched it between both hands. "I'm kind of willing to let it eat you, too."

Rahel quirked only the slightest smile before turning into the brush to leave him alone. Sometimes, he displayed more character than she gave him credit for.

Tangled vines and rotten leaves padded her footsteps, filtering the stench of rich, wet dirt up into her face with each step. No challenging roar interrupted her approach, and she brushed heavy leaves from her face with a growing certainty about what she'd find. When the notebook said she was only five strides away from Arjuna, she looked between the trees to where the notebook pointed and wasn't the least surprised at what she found. Only that there was so little of it.

"Hot damn." She kicked the bone closest to her, and it tumbled among the undergrowth to land near the picked-clean skull.

Her pack clattered when she flung it happily to the ground. "Tovin?" Wels called from behind her. "Are you all right?" She ignored him, stuffing both notebook and pistol into her pockets while she knelt among the scattered remains.

It didn't take a paleontologist to recognize a tiger skull, given the circumstances. Vertebrae littered the ground nearby, cracked slabs of cartilage flak-

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ing to pieces between them. Few other bones remained; those that did bore the cracks and gnaw marks of various teeth. Digging through the loam where the shoulders should have been, Rahel found the thumbnail-sized chip with little difficulty. Once the dirt was blown away, she could even make out the silvery etching along one edge: ND8737-55 "ARJUNA." She pulled out her notebook to verify the signal, but a grin already tugged at her face before the code flashed greenly across her screen. Pay dirt.

"What is it?" Wels had managed to get right behind her without her even knowing. She was too delighted at the prospect of leaving him and New Dallas to care.

Rahel slipped the tag into her notebook, then reached back for her pack. "This is Arjuna's signal tag."

Wels nudged her gear closer with his foot. "What's it doing here?"

She rapped her knuckles on the skull, chuckling. "This is Arjuna. I'd say we've found your tiger, Mr. Prelate." Technicalities—everything from here on in was technicalities. She could even be pleasant without resenting it too much.

Wels watched her harvest samples from the one remaining long bone, a rib, a vertebra, and the skull. Then—for the sake of completeness, and nothing else—Rahel scanned the immediate site on hands-and-knees, taking whatever samples struck her as potentially useful, trying to pretend there was still some mystery so she wouldn't be sloppy. Only after she'd logged each sample, stowed them in her pack, and stood, did Wels move forward into her line of vision to frown down at the remains. "So what happened?"

She shrugged. "Something ate him." She slipped into the jungle, headed back the way they'd come. Maybe when she was finished here, the Ark would let her go back to her coyotes on Eden for more than a few weeks at a time. "Actually, a lot of somethings probably ate him, but it was probably another tiger that did him in. Males fight over territories, and sometimes one of them dies. Not often, but often enough. There certainly isn't much else around here that can kill an adult tiger."

At this stage, she didn't much care how Arjuna died, truth be told. She knew it hadn't been Wels's people—they'd abandoned Melissa Pass more than a week ago, and Arjuna's remains weren't any older than that. The colonists wouldn't have bothered calling Noah's Ark if they'd already killed the tiger themselves. There'd also been no signs of traps or poisons around the remains. If nothing else, Rahel gave Wels credit for basic honesty—she couldn't believe he'd attempt something so stupid as calling for a proctor while planning to sic Colony cops on the animal while the proctor was on planet. Which all meant Arjuna had died from natural causes—Nature, in this case, taking the form of some bigger, meaner tiger who needed more room to do his tiger stuff.

Either way, Rahel was out of here.

After all, they'd placed Arjuna at the murder sites. Arjuna was now dead. While that cheated the case out of its neat little sense of closure, Rahel didn't mind. She wasn't in this job to create aesthetically pleasing scenarios, she

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was in it to solve them. Or, at least, to recognize when they'd been solved for her.

"So does this mean we're finished here?"

She smiled at Wels, jostling him with her elbow. "It means *I'm* finished here."

Wels fished out his pistol and handed it across to her. "I guess I won't need this anymore, then." He stuffed his hands in both pockets. "What happens now?"

"I go home." Rahel spun the pistol in the air in front of her face, then caught it between her palms. "You stay here. We never see each other ever again."

"Are you taking your dog with you?"

Rahel flashed him a curious frown. "Of course I am."

Wels smiled without turning to look at her. "Then I can live with that."

Not if he talked a whole lot more, he wouldn't. But he was smart enough to stay silent throughout the rest of their walk, so Rahel didn't have to kill him before they got back to the pachyderm.

Rahel saw the open outpost hatch through the pachyderm's chameleon, and all her pleasant feelings boiled completely away. "God*damn* it!"

Wels slammed to a stop, letting Rahel's momentum carry her past him. "I didn't—" he stammered. "It was closed! I swear, it was closed!"

"*I* closed it!" She thundered one fist against the all-but-invisible pachyderm as she rounded it. Wels's image flickered and warped at the edges of her sight, reflected through the chameleon from farther and farther away. "I even latch-locked the damned thing! No wonder the tigers thought you guys were easy prey, what with your god-dammed glow-in-the-dark outposts and your doors that won't stay closed. Basa!" Her calls and whistles startled shrieks from the birds all around them. "Basa!"

Wels hung back near the pachyderm's nose while Rahel circled the outpost, calling and swearing. She'd never in all his little life left Basa alone outside the pachyderm, so had no idea what he might do or where he might go in alien terrain. He wouldn't even be outside alone now if she hadn't let misplaced consideration for Wels's wardrobe get ahead of her dog's safety. This was her own damned fault for trusting in anything besides herself and her own Ark equipment.

When she pushed past Wels again, aiming for the open hatch, he called helpfully, "We weren't gone for long. I'm sure he didn't get far."

"You'd be surprised how far those stumpy little legs can get him." She barrelled through the hatch and nearly skidded onto her butt on the smooth floor. "Basa?"

She noticed the ribbon of blood before she noticed the smell.

Beyond the second doorway, only the crooked smear of red and a bouquet of tiny, bloody footprints gave any indication what had happened. Rahel shuffled two steps into the room, feet suddenly numb and heavy. A scrap of black, white, and pink lay tumbled in the blood, but she had to crouch beside it very slowly and turn it over with one finger before she could recognize it for

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a tiny canine jaw.

"What happened?"

Wels's question so closely matched the ones churning in her own brain, she didn't even realize he'd said anything at first. She climbed to her feet and stumbled back toward the door, trying to make her mind pin down the steps she needed to take next. But her thinking had gone as numb as her hands, and it fumbled around in her skull like a drugged bear. She collided with Wels in the doorway, frowning in confusion to find him blocking her. "Get out of my work area."

The prelate shook his head and moved to intercept her when she would have stepped around. "We still don't know what happened to the doors. I think I should—"

"Get out!" She stiff-armed him in the chest, slammed him with both hands and propelled him clear to the main entrance. He caught himself in the outside doorway. She left him there, snatching up her equipment pack and retracing her steps to what was left of Basa's corpse. Every minute passing stole a data point from her chain, and she'd kill Wels for real if he squandered too much of her time.

"I could wait here with you." His voice echoed flatly from the other room. "I won't get in the way—I'll just watch the doors."

Sample slides slipped and clicked as she dug them out in shaking hands. The blood—the blood was Basa's; she was nearly positive of that. The jawbone, too. But there were hairs yet, and saliva traces, and tiny dead skin cells from the soles of its feet. And the blood, too, she decided. Just to make sure. A hundred little informational bits that could be used to trap any killer in the universe, all no more than an hour old.

If only she could keep from crying long enough to harvest the samples without contaminating her field.

Rahel spent three hours just in the room with Basa's remains. Everything that might possibly be useful found its way onto a slide and into her pockets. Once she was certain nothing more of value remained, she checked all through the outpost for any other exits. There were four—all still hard-locked from the inside. Only after she'd made sure of the hatches, sealed the rooms behind her, and stowed her equipment by the front door did she set about carefully mopping up the red-brown blotches crusted onto the outpost floor.

When she was done, she retrieved the only part of Basa that couldn't be sopped up with a rag. The terrier's tiny jawbone wasn't even enough to fill her palm. Cupping it between her hands to save it from any further harm, she carried it gently outside, to the trees beyond the pachyderm's nose. There, she found a sun-flecked spot among a froth of bobbing ferns—a spot with just enough twigs and leaves for a little dog to chew, and just enough dirt for digging and happy rolling. Then she plowed a deep trough with her fingers and snugged the tiny body part inside.

She could have kept the jaw for cloning, but she refused to do that to any creature that had always been as unique and independent as Basa. She'd picked him special, the runt from a litter of live-whelped puppies, not from a list of vat-cloned blastulas. There was no

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other dog exactly like him, and there never would be again—he was the glorious result of the random magic of genetics, never the same trick twice. Rahel wouldn't lessen his place in her life by commissioning his replacement as if he were a broken piece of equipment.

"You were a lousy little predator," she whispered gruffly. Then, gripping Basa's favorite pocket in both hands, she ripped it from her vest with a series of hard jerks. It stuffed clumsily into the oblong hole, but two handfuls of dirt packed it down well enough.

When she'd patted the dirt in tight and made the grave as invisible as her pachyderm, Rahel knew Basa was well and truly gone. Bowing her head to rest on her knees, she pressed her hands against the bulge of sheltering earth, and cried.

The pachyderm's interior was leaf-cluttered and sun-splashed, just like the jungle outside. Rahel paused inside the hatchway, caught off guard by the exterior display when she'd wanted the comfort of human-made darkness. She couldn't remember if she'd left the walls reflecting the outside, or if Wels had called up the display in some misguided effort at sympathy. Either way, it wasn't what she'd hoped for, and left her feeling all the more angry and out of control.

Tossing her pack onto the seat in front of the test station, she dug into her pockets for two attack sites' worth of slides. They piled onto the station with a great sliding clatter, one careful handful at a time. The AI beeped in welcome, lighting its screen in response to her presence.

MATCH TEST 2
****JOB ABORTED****

Gene lesion load: Structural-5/Regulatory-8

Primary viability default: Collagen A-chain truncation; helix formation prohibited.

Speculation: Post-mortem embryonic sample; Severe teratogenesis

Recommendation: Reharvest and re-evaluate

Staring, Rahel touched a finger to the newly-wakened screen, flipping past pages of supposedly-helpful text to study what charts it had compiled from the actual spins.

"It said that when I got in. I didn't touch anything."

She looked for Wels over her right shoulder. He sat in the pilot's seat, the chair turned toward the rear of the craft instead of toward the front. Catching sight of the jungle through the viewport behind him, Rahel wondered if he'd spied on her private burial. The apologetic stoop to his shoulders told her more than she really wanted to know.

Cheeks burning with embarrassment and walled-up tears, she turned back to her AI and her samples. "What was I running?" Right now, the bands of color and rows of numbers refused to punch through the cotton webbing of her brain.

Wels's boot heels clicked quietly on the deck as he came down to join her. "My samples from inside the outpost." He appeared at the edge of her vision, chewing on his lower lip. "What does

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it mean when it says that? It didn't do that when you ran your samples."

Little by little, the dim wrongness she sensed in the spins congealed into almost-recognizable chaos. She pulled up the results from her first set of outside samples, then split the display to run those spins alongside Arjuna's file and Wels's indoor samples. Sandwiched between clean bands of tiger DNA, the aberrations in Wels's samples leapt out like lightning in a stormy sky. Her shock dissolved under a wash of slow amazement. "Oh, hell . . ."

"Oh, hell what?" Wels fidgeted unhappily, jittering with apprehension. "What's it saying?"

"It's saying your slides probably came from aborted fetal tissue that laid around for a day or two before we sampled it." She made the station spit up Wels's slides. "Which is bullshit. Fetal tissue never attacked anybody, and fetal tissue doesn't have hair."

Wels glanced down at the hair sample she tossed to the desk in front of him. "So did I ruin the samples? Did I collect them wrong, or something?"

"No. It isn't you." Dumping the tiger files, Rahel set the station on searching up a whole new data pack.

"Then what's the matter?"

"What's the matter is—your samples don't have Terran DNA."

Frantic AI prompts reflected in the prelate's blue eyes. "Meaning?"

"Meaning . . ." Rahel fanned out her slides on the station, picking through them like a hand of cards, ". . . whatever killed your miners isn't Terran native, and it didn't come from Noah's Ark."

"Oh, my God . . ."

"Yeah." She started flipping the slides she needed from one hand to the other. "Oh, God."

The AI said it would need two hours to verify whether or not Wels's samples contained New Dallas DNA. Forty minutes of that, of course, would be loading and sorting the Ark's New Dallas genetic data for comparison. Twenty-three hours after that, Rahel could pull a specific species match and know for sure what they were after. Until that time, Wels seemed determined to pace the pachyderm from stem to stern, blurting questions to which Rahel didn't always know the answers.

"Is this outside our Charter with the Ark? Are you obligated to see this through?"

"I'm not obligated to do shit, but I'll stick around long enough to sort everything out."

"Is this the same thing that killed your dog?"

"I don't know, Wels. Shut up."

"Can we still relocate this thing once we find it?"

"Wels, you ask me one more goddamned question, and I'm gonna hang your skinny ass out the door and drag you half-way across the continent!"

That shut him up, at least, and gave her a chance to check New Dallas's indigenous records for large predators before crawling off to bed. Wels's nervous company wasn't the same as having Basa around to grumble and chew, but it beat the hell out of Wels's fretting. Rahel floated into sleep that night frustrated by her fruitless search, and missing the warm little body that used to snore against her hip.

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She jerked out of a sleep made nonexistent by lack of dreams to find Wels's white face hovering in front of her in the dark.

"I'm sorry to wake you." The jungle still filled the pachyderm wall behind him, looking as wild and restless as his sleep-tousled braids. "But there's something outside."

"This is a jungle. There's always something outside." Still, something about the rapid rise-and-fall of his breathing told her he wasn't just talking about some snuffling insectivore or a drape of overlarge fly-by-nights. So far, Wels had been a lot of things, but he wasn't a coward. "OK . . ." She kicked off her covers and swung her feet to the deck. "Show me."

He padded barefoot into the main compartment, where the display walls offered the widest view of the unbroken jungle. Rahel stumbled to a stop next to him, rubbing the sleep from her eyes. He ducked a little to point beyond a web-work of strangle vines. "There," he whispered. "It comes and goes."

She couldn't see anything in the dark—not that she'd expected to. Leaning around him, she tapped the AI awake. "Night-sight. Light enhancement." She didn't know why she was whispering. Probably because Wels was. It wasn't as if anything outside the pachyderm could hear them.

"OK."

Dawn seemed to flash across the walls, sweeping detail through the outside display. Leaves, and limbs, and ground clutter suddenly sharpened to an intricate black-and-white, carving the nighttime jungle in images normally reserved for animal eyes. Peering into the grey-shaded chaos, Rahel forced herself to see what was really shaped by the patterns, not just what her lazy eyes would tell her. Even so, she might never have spotted their visitor against the jungle if it hadn't stood and moved.

When it broke cover to trot a few steps closer to the outpost, something about its stiff-legged gait punched Rahel in the stomach with dizzy recognition. It was Basa, she thought. The same fidgeting feet, the same eager shake of its head. Then she noticed the heavy, square muzzle, the trim, rounded ears, the flat back and misjointed limbs, and she wondered how she could possibly have mistaken this waist-high monster for her little three-kilo terrier. Light-gathering eyes— forward-facing and nearly as big as her palms—flashed fluid and white when it scanned the artificial clearing.

"I'll bet it sees us."

Wels scowled at her, one eyebrow arched with skepticism. "All the way in here? I doubt it."

Rahel grinned despite herself. "I don't mean *us*—I mean the pachyderm. With eyes like that, it's got to have kick-ass night-sight." She turned to watch it stalk around the pachyderm's nose. "Looks like an all-around good design."

Wels kept tight to her right shoulder as she moved. "What is it?"

"Haven't the faintest." She crossed the pachyderm to press her nose to the wall beside the hatch, watching their visitor sniff around the closed outpost door. "External visual: Give me an ID on that thing against New Dallas indigenous life."

"OK." The AI's conversational tone

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sounded suddenly loud in all the quiet. "I can have a visual match in 5.17 minutes."

"Go for it."

"OK."

Wels kept his questions and comments to himself while they waited for the AI's results. Rahel stayed as close as she could to the display wall, drinking in every hair and muscle on the creature; she felt like she'd been drawn out into the darkness beside it, close enough to hear its snorts and smell its hide. Flat nostrils whuffled nose-prints back and forth across the outpost hatch, and camouflage shadow-patterns swirled over the shoulders and squared-off hips. Grey and black, she guessed. Maybe brown. Its rump rounded off to a tailless slope, and the joints on its rear legs bent forward instead of back, unlike most Terran quadrupeds. In keeping with its leg structure, all four feet splayed flat to the ground, heels and toes pressing handlike prints into the grass. Rahel focused on the four blunt digits, studying how the toes gripped the outpost walls when the creature climbed into an awkward standing position against the hatch. Fascination clung to her right up to the point when the creature closed clumsy fingers on the door's locking mechanism and deftly punched up the open code. Her skin chilled clear to the bottoms of her feet.

"Oh, shit!" Wels slammed both hands against the display beside her, swearing at the creature's reflection as it disappeared into the outpost. "How did it do that? How did it know how to do that?!"

Rahel didn't know. She didn't care. All that mattered now was that she suddenly knew precisely what kind of thing had killed her dog. Shoving back from the wall display, she turned and darted up into the cockpit.

"Where are you going?"

"Results: I'm unable to find a visual match for the subject outside the pachyderm."

"Shut up!" Rahel aimed the command at both Wels and the AI. As usual, only the AI obeyed her.

"What are you doing?" Wels bounded into the cockpit beside her. "We're not just going to leave it here, are we?"

"Keep out of my view." She flopped into the pilot's chair and woke the external snooze gun, telescoping the turret. Glowing cross-hairs appeared on the wall display, centering on the lower third of the open outpost hatch. "Come on," she whispered. "Come out to mama."

Wels crouched behind her chair, carefully not touching her or the console. "Just what is it you're intending to do?"

"Shut up."

A flash of light, dark, then light again appeared in the outpost hatch. The creature's dinner-plate eyes blinked slowly against the inside darkness. "Come on . . ." She gripped the trigger until her hand shook.

The creature slipped from the outpost with long, languid strides. Rahel's cross-hairs rode it silently piggy-back, sitting on its shoulders like a high-tech firefly. It paced beyond the pachyderm's nose, then paused above Basa's tiny grave to dig at its ears with one hind foot. Rahel dropped it with a single pulse, but squeezed off a second shot

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just to make sure it was snoozed. She wished it hadn't toppled onto Basa's grave, though.

Wels nearly fell over when Rahel shoved out of her seat and ran into the back for her clothes. Her pants were still crumpled at the foot of the bunk, her boots tumbled nearby. While she yanked trousers on right over her night clothes, Wels rose to his knees and leaned over the console to stare outside. "Is it dead?"

"Of course not." She stamped into her boots, then snatched up her pack on the way to the door. "But I've got about two seconds to get out there and collect my samples, or we might never find out what's going on around here." The snooze would last a lot longer than that, but she didn't want to waste even a moment of it explaining anything to Wels.

He rolled to his feet as she hurried past. "I'm coming with you."

"The hell you are." The hatch popped open with a hiss, bathing her in wet jungle air. "You even try, you goddamned amateur, and I'll give up and leave you here with it. I swear I will." She muscled the door shut before Wels had a chance to answer.

No need to pause and let her eyes adjust to the night, not with the real-time display on the inside. Dashing across the floor of rotten leaves, she slowed to tip-toe near the creature's hindquarters. Ribs rose and fell like heavy hammer blows, and grunting breath scattered the loam in front of the thing's blunt muzzle. Rahel circled it silently, finally sinking into a crouch behind its shoulders. This way, she could at least see the pachyderm while she worked and still have a half-clear shot at running for it if she had to.

Hair samples. Tissue samples. She would have killed for detailed fluid samples, but didn't dare take the time to harvest them. The vidcam roamed from ears to tail, drinking in more information than Rahel could have hoped to gather by sight alone—from the cap of black fur between its speckled ears, down its dorsal stripe, and back across its glossy chest and sides. Its half-lidded eyes sparkled a striated amber, with no interior lid to obstruct her view of them. She'd just pocketed the last of her slides and dug into her pack for a signal tag when the one visible pupil bloomed an iris-swallowing black, and air flooded the creature's lungs with a wakening roar.

Rahel scrambled back as the creature lurched to its feet. Too soon—it came around far too soon for her to trust that the snooze pistol in her pocket could put it under again. She dug out the smaller weapon anyway, not intending to fire unless the creature moved on her. If it was like almost every other animal in the galaxy, it would just as soon vanish into the jungle as face a human scientist. Unfortunately, there was only one way to find that out for sure.

"Tovin!" Wels burst into existence beside the chameleoned pachyderm, a snooze pistol gripped in both hands.

The creature dropped its head and spun toward the prelate with a speed that kicked Rahel's heart into her mouth. "*No!*" Her voice sent night creatures crashing off into the jungle all around them. "Get back, damn you! Get back!"

Wels stubbornly stood his ground—

—and the creature flinched with a

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guilty groan, mincing backward by four unhappy steps.

"Back" was four steps. "Off" was keep your feet on the floor. "Down" he never listened to anyway.

My dog, Rahel caught herself thinking. *That's my dog!* Her hands suddenly trembled as if the snooze pistol were too heavy to hold.

The creature grumbled, fidgeting, but didn't try to move forward again. Wels's wide eyes met Rahel's over the thing's hunched shoulders. Did he see it, too, she wondered? Or did she only imagine it, caught between interrupted sleep and missing her dog? Wels's face spoke only of fear and confusion, his stiff body stance saying he wanted to take action but had no idea what to do. Rahel wished inspiration would strike and burn some special certainty into her brain. Instead, her lungs felt hot and empty, and all she kept seeing was her dog's belligerent expression and broken down ears against a backdrop of amber eyes and patterned stripes.

"Get back in the pachyderm." She tried to keep her tone even, hoping the gentle volume would carry across the distance between them. "Just move smooth and calm, and step back inside." Wels opened his mouth to say something—anything, she didn't care what—and she cut him off in the same level tone. "Don't say a word. Don't try to shoot it. Just get back in the pachyderm, or we're both dead. Now go."

Nodding faintly, Wels still fingered his snooze pistol as though considering a spate of last-minute heroics. His left hand reached behind him, though, tracing the pachyderm's contours in the air. When his arm disappeared through the open hatch, he shuffled backward very slowly.

Rahel flicked her gaze to the creature when it grumbled and shifted its weight. Its front feet jigged a little dance, chewing up fistfuls of rotten dirt in anticipation. Rahel darted forward on the strength of her instinct alone. "No! Bad dog!" Wels flung himself inside the pachyderm, leaving her alone while the creature swung to face her, cringing. She scowled as fiercely as her thundering heart would allow, shaking her finger in its face. "Bad dog bad dog *bad dog!*"

Each shout seemed to smack the animal like a physical blow. It retreated from her steady advance in a panicky scrabble, finally turning to flee when its front end overran its rear and tumbled over itself. Rahel waited until she heard it crash headlong into the undergrowth before bolting for the pachyderm herself.

At least Wels had enough wit about him to keep the hatch open until she got there. Rahel slammed the door, pressing her forehead against the metal and breathing deeply through her mouth to try and ease her twitching muscles. Behind her, Wels dissolved into swearing, seeming to vent her fear as much as his.

"What did I just see out there?" he finally blurted, stomping back and forth in the cramped hatchway lock. "What was that?"

"A big, huge, ugly native." The thought of volunteering anything else made her stomach knot. "I don't know what it was."

"But am I right?" He paused right behind her to lean over one shoulder.

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"Was that your dog? In a big, huge, ugly body, but somehow still your little dog?"

Hearing him admit that lanced new fear straight through her. She didn't like feeling so suddenly drowned by a flood of uncertainties. "Yeah," she sighed, pushing away from the door. "I don't know how, but I'm pretty sure that's at least partly my dog." Only Basa wouldn't have known how to hide in a jungle, much less open an outpost door. There were still plenty of questions to be answered.

Sliding down the wall to squat on the floor, Wels groaned with shaky laughter. "I don't think I'm going to enjoy this. He didn't like me very much the first time around."

Rahel snorted, sliding past him to dump her gear on the testing station. "If even half of what I'm thinking comes up true, Wels, he's gonna like both of us a whole hell of a lot less."

Rahel didn't get back to sleep that night. Wels surprised her by catching another five hours in the cockpit—she hadn't given him credit for such steady nerves. Or maybe he just wasn't used to keeping screwy hours.

The AI spit up its match test results a couple hours after their midnight visitor disappeared into the trees. "NO ADEQUATE GENETIC MATCH ON FILE." Small wonder. Rahel spent nearly an hour flipping through all the test results, drinking in details along with cups of lukewarm coffee. Wels's sample slides from the outpost were definitely of New Dallas origin, but the Ark had nothing on record to match those genes.

Nothing? She snorted and set the station on comparing her samples from Basa's attack site with the results of Wels's match test. How in hell could Noah's Ark survey an entire biosphere and manage to miss something as large as this predator? Could it be there was only the one? Then where the hell had it been all this time?

"Split screen. On one: Display full-body still of last night's intruder."

"OK." After a moment, the AI gave her a full-body shot—color adjusted for daylight viewing—of the thing snoozed out on the ground for sample taking.

"No, no—give me one of it standing up, moving around. I want it to look like it's alive, for crying out loud."

"OK." This time, the creature was caught in mid-stride as it paced beyond the pachyderm's nose, huge eyes glowing.

"Better. All right—on two: List and queue all still visual records of New Dallas carnivores that aren't obviously reptilian, aquatic, or avian. Display in descending order, by size. I'll page through them manually."

"OK."

Lots of variety, lots of lovely examples of how any ecological niche might be filled, but none of them resembling Rahel's new-found predator in even a cursory manner. And none of them, really, suited to be capstone predator in New Dallas's jungle environs. That's why Noah's Ark had agreed to seed the tigers—lots of prey, not much competition. Rahel wondered if anybody had ever put much thought into the Whys of the New Dallas food chain, instead of just the Whats.

Although, come to think of it, the Whats were the major problem here.

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By the time she got down to a voracious little predator slightly smaller than a Terran shrew, Rahel was ready to start all over again, this time with the healthy prey population. Maybe looking at what there was to eat would give her some ideas.

Wels interrupted her partway through by rolling awake and groaning at the light. "What time is it?"

"Dawn." Rahel glanced at the chronometer above the station. "A little after. I left you some food in the back."

He grunted a reply, then shuffled past while knuckling sleep from his eyes. Rahel pulled aside the records for the current continent and started comparing picture to picture, spin to spin. Wels reappeared just as she started the comparisons again, this time among the species most populous around Melissa Pass.

"Jembels." Wels grinned, recognizing the spindly-legged herbivore on the station screen. He leaned back against the doorway to the cockpit and swept his unbound hair over the front of one shoulder to finish brushing it. "I can guarantee that's not what attacked us."

Rahel flashed him the corner of a scowl, not turning her attention from the screen. "How would you know? You're a city boy." She brought up two more samples, and the spins lined up exactly as she'd thought they would.

"City boy I may be," Wels allowed. "But the jembels are getting pretty citified, too." He tossed his brush behind him into the cockpit, then set about separating his hair for braiding. "There must be a billion jembels in the Colony quarter alone. They even come into Colony Central and trample our flower beds."

Thoughtful, Rahel spun her chair to watch his fingers whisk his hair into a tight rope. The braid coiled as it grew, its own little DNA helix of blondness and length. Suddenly conscious of the tightness in her neck, Rahel rubbed at the back of her shoulders with a sigh.

"I'm not a scientist, but . . ." Wels sank onto the cockpit steps, finishing off his braid by wrapping it into an out-of-the-way bundle at the nape of his neck. "I've been thinking."

Rahel smiled a little, chasing away thoughts of DNA and tigers. "We don't have a corner on thinking, you know. We just do it better than you."

Settling back with his hands around one knee, Wels didn't smile back. "That thing we saw last night—it remembers stuff about the other animals it eats, doesn't it?"

Serious time, then. Rahel nodded, straightening in her chair. "Something like that, yeah."

"Well, here's what I'm thinking." He pursed his lips and frowned thoughtfully. "One of the tigers from Noah's Ark killed and ate Del Harbin." He flicked blue eyes up at her. "You found enough physical evidence at his murder site to prove that, right?"

When she nodded, he echoed the gesture, his gaze fixed in the imaginary realm of thought. "OK. So then our new monster comes along. It eats the tiger, and because of that it remembers that people taste pretty good. So it eats one of the miners, and suddenly it knows how to break into the outpost and eat everybody else. Including your dog. You following so far?"

Rahel was beginning to sense where

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this was leading. "Considering you're only just making this up, I'm interested. Go on."

Wels shrugged and settled back against the steps. "What happens if we feed it something else? Like a rabbit, or a herd animal?"

She acknowledged the suggestion with thoughtfully raised eyebrows, rocking back in her own seat. "It might just decide it only wants to chew on carrots and trample marigolds." She nodded. "Not a half-bad idea, actually. But why hasn't it happened naturally? What's the damned thing been eating since your miners?"

Wels frowned. "I don't know," he admitted. "Maybe nothing. What does it eat normally?"

"Don't know. The Ark hasn't ever heard of it before. But I'll take a guess." Rahel swung around to tap a finger on the AI screen behind her. "The jembels."

Wels pushed to his feet to stand behind her, face blank with surprise. "What brought this up?"

Rahel combed her own dark hair away from her eyes, wishing she'd thought to shower before putting in her all-nighter. "When the Ark initially surveyed New Dallas, they listed a moderate but healthy jembel population—nothing like the numbers my AI gives me now, and nothing approaching what would be needed to push jembels down into Colony Central. I just figured jembels had suffered a population explosion. But look at this—" She magnified the jembel spins already on the screen, peering back at Wels to gauge his reaction.

"By now I know that those are DNA." He leaned so close over her shoulder she could see the pale stubble on his cheeks. It was a little strange to think of Wels unshaven.

"They're graphs of DNA spins." She tapped the screen, drawing his attention to the three striped diagrams in front of them. "See anything different from this one, to this one, to this one?"

Squinting, Wels leaned in far enough for the screen light to tinge his hair with grey. "No."

Rahel smiled. "That's the point." When Wels angled a frown at her, she stabbed a finger at the screen again. "Three different jembels, but almost identical DNA. You hear all about this in genetics classes."

Wels shook his head, straightening. "What's this got to do with our problem?"

Rahel turned her chair again to face him. "This sort of genetic closeness in a species usually means that, at some point in the past, that species was within a few animals of extinction. With only a handful of progenitors to choose from, the gene pool boils down pretty quickly to the two or three DNA combinations that are actually any good. You end up with a new population of animals who are closer in gene-type than most brothers and sisters."

"The punch line?" Wels asked.

"A good third of the prey animals on this continent exhibit the jembels' genetic closeness."

He frowned, toying with one earring. "I still don't understand."

Rahel clapped her hands to her knees, sighing. She knew he wasn't trying to be stupid—he was just a politician, he couldn't help it—but finding words to

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explain this to him wasn't proving to be easy. "OK, let's play make-believe. We've got evidence that a large part of this planet's zoology has come very close to extinction at some point in the past. The proctors who first surveyed New Dallas guessed that some sort of natural disaster must have stressed this ecosystem to the point of near collapse—earthquakes, fires, plagues, something—and thus almost wiped out a lot of the life here. But what if it wasn't any of those things? What if their natural disaster was our predator?"

Wels pulled back with a skeptical scowl, crossing his arms over his chest. "*One animal* could do all that?" He paced back to the steps and sat. "Give me a break."

"Not one animal," Rahel admitted. "But I'll bet a decent population of them could."

"We don't have a decent population of them."

"Maybe we do." She stood to stretch her arms over her head. "Where did the one that's terrorizing you guys come from? Why didn't any of the Noah's Ark safaris ever notice them before?" She shrugged and swigged the last of her coffee. It was hopelessly cold; she spit it back into its cup. "What if they prey on an ecosystem until they almost destroy it, then go into hibernation or something until the prey populations can renew themselves? That could take years and years, both ways."

Wels watched her head toward the bathroom stall, stripping out of her vest and boots on the way. "Does this mean you think I'm right—that feeding it a jembel or two might fix things?"

"It means I think it can't hurt." Lifting up one foot, then the other, she yanked off her socks and tossed them randomly toward her pile of laundry. She quelled an automatic impulse to hide the laundry from Basa. The little blossom of grief that followed left her wondering if, after all these years with the dog beside her, she would ever get used to having him gone.

"All we have to do now," Wels called as she stepped into the stall to finish stripping, "is figure out where to get a jembel."

Rahel cracked the door to throw her pants back at him. "Oh, for God's sake, Wels—the way you talk, we should be able to run outside and stumble over one."

"True."

"So what we really have to do is figure out how we're going to find the damned predator." The first burst of water felt fine and hot. "I didn't get a chance to tag it last night."

Wels waited for the water to stop before yelling, "I've thought of that, at least." When she didn't answer right away, he added, "I'm just full of surprises, aren't I?"

Finished with her soaping, she yanked the water on again to rinse. "So it would seem. What's your plan?"

"You're not going to like it."

"I don't like anything about you, Wels. How bad can it be?"

"You might be surprised."

He was right—she didn't like it. But it made a certain amount of sense, and she had to grant him that.

"You can't blame me," Wels pointed out while they hauled the dead jembel back to the pachyderm. It hadn't

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taken more than an hour to find a herd worth gleaning. "It's not my fault the damned thing thinks it's *your* dog."

Damned if he wasn't right about that, too.

Back at the pachyderm, Rahel talked Wels through the short list of things she most wanted him to remember. She made him practice telescoping and shooting the snooze cannon, and told the AI how to get Wels and the pachyderm back to Colony Central without her.

"But don't wake up the cannon, don't come outside, don't do *anything* unless that thing comes for me. And then *all* I want you to do is snooze it and get out of here." She hefted the jembel to her shoulder, its horned head flopping limply against her back while she pocketed a tagging gun. "The Ark can send somebody to fetch my pachyderm and my records."

Wels followed her as far as the pachyderm hatch. "Can I at least retrieve your body? I hate like hell to imagine that thing pretending it's you."

"I hate even more to think it might end up being you." She opened the hatch one-handed and stepped outside. "You just leave my body and get. There'll be nobody to report this if it kills both of us, and that'll make this whole damn safari a bust." Peering at him severely, she pressed, "Now, I know it's hard to tell the truth when you're a politician, but you either promise to leave me if it comes to that, or I'm taking us both out of here now."

He drummed slim fingers against the edges of the hatch, his brows tied into fretful knots. "All right," he sighed at last. "I promise."

Politician or no, she decided to take him at his word, and let him close the door.

Sunlight cut a ragged swatch out of the jungle, bleaching the grass in the outpost clearing to a flaxen to match Wels's hair. Rahel paced clear of the pachyderm with the dead jembel warm and heavy over her shoulder. Their alien predator had returned to the outpost at least twice now—whether driven by memories of food or by memories of human companionship, Rahel couldn't say. She only knew that the thing she'd encountered last night was at least partly her dog, even if it was also partly something else. If Wels was right, that meant she also had some control over it.

At least, as much control as she'd ever had over Basa.

Stuffing fingers between her teeth, she loosed a whistle loud and high enough to shiver the leaves on the trees. She gave Basa a chance to answer, and the jungle a chance to recover, before whistling a second time, louder. Quiet gathered around her while native chattering and rustling died away. "Basa!"

Buzzing carrion flies crawled from the jembel's carcass onto her cheek, tickling her hairline, tasting her sweat. Rahel swiped at her face and realized her hands were shaking. *Not good*, she thought. *Dogs can sense fear.* Then, feeling a hysterical laugh coming on, she fought the impulse down. If she'd known she was going to be out doing something stupid like this, she'd have made sure she got some sleep last night.

"Basa!"

The creature barreled out of the undergrowth with a great cracking and crashing of branches. Rahel stumbled

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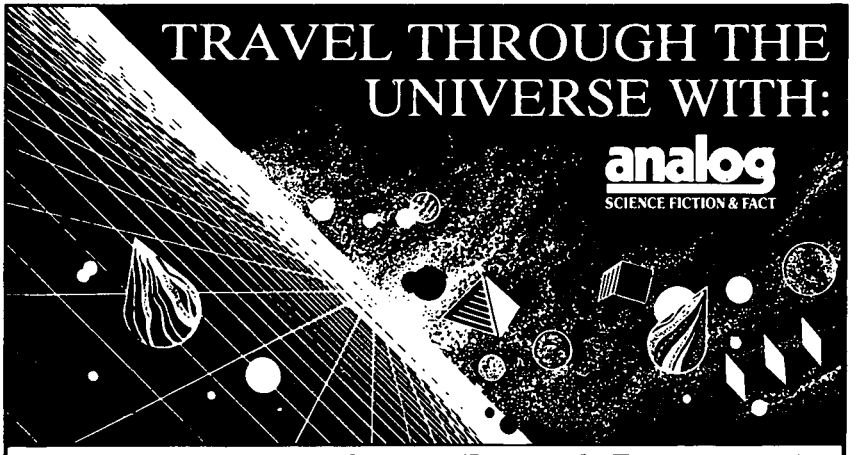

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back a few startled steps, fear swelling inside her until it crowded out all breath and thought. When the thing skidded onto its rump in front of her, a dense curtain of heat and body odor swarmed around her. It all felt so weird and wrong; Basa's breath had always smelled like dog food.

". . . good dog . . ." Her voice, tight and breathless, sounded like a prepubescent choir boy's. "Good bud." The creature gazed up at her with eyes as flat as cracked glass, its tailless hind end quivering. Rahel couldn't have fit both her hands around its muzzle, yet she still found it queerly easy to slip one hand along its skull to rub at the backs of its ears. "There's a good boy."

Its fur felt soft and slick beneath her touch, not at all like Basa's short, stiff coat. Working her hand along a cording of thick muscle, she reached up to her shoulder with the other hand and dragged the jembel forward. "You want a yummy, bud? God, I hope you want a yummy." Basa certainly didn't know how to hunt—she hoped this thing was starving.

It jerked nervously away when the jembel thumped to the ground. Rahel lowered her hands slowly to her sides, trying not to jitter with anxiety. "Come on, dummy. Do you want to eat or don't you?" She crouched to slap the jembel's flank. "Lunchtime."

Basa's quirky expression of interest—head cocked, one ear upright, one ear down—looked perverse on the massive features. It minced forward again to snuffle the carcass. Reaching for its scruff with one shaking hand, Rahel fumbled for the tagging gun in her vest pocket. "Yummies, bud," she whispered. "Eat up."

It didn't even flinch when she injected the tag beneath its skin. The crack of its teeth through bone, though, brought a growl up through its throat too deep and liquid to belong to Basa. Rahel jerked away, gasping, and startled them both. The eyes it rolled up to glare at her seemed wider than before, but still oddly doglike and frightened. She remembered Basa the one time they'd fought over a slab of raw steak he'd stolen from the Ark commissary—she'd managed to take the meat from him, but not without earning a five-centimeter tear in her hand. She shuffled backward slowly, torn between whether she should encourage its ill behavior or somehow discipline it.

The creature saved her from a decision. Sinking teeth into jembel haunch, it scuttled awkwardly backward, still growling. The limp little body dragged a trail through weeds and grass on its way toward the trees. Rahel put her own distance between them, not stopping her backward drift until she collided with the chameleoned pachyderm. By then, the creature had vanished into the jungle with its dinner, leaving only the agitated plant life to wave a silent good-bye.

For a long while after it left her, Rahel stayed pressed to the pachyderm, staring after the monster. She just couldn't make herself go back to Wels, not with guilt raising such a ruckus inside her. Wels might be right, after all. The jembel might just do the trick, and their predator might soon retain no memory of Rahel Tovin or her little Jack Russell terrier. As close as that was to letting her dog die all over again, it

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seemed only right she stand silent vigil for as long as she felt safely able.

The sun crept slowly across the sky that day, dragged at by both the hungry jungle treetops and Rahel's impatience. She fought off insanity by inspecting and filing every scrap of data they'd collected on the creature so far, notating videos and stills while Wels paced around the cockpit and fidgeted by the front viewport. She listened to the crisp metronome of his boot heels and his long, fretful silences until she thought she'd have to hamstring him just to make him sit down. Instead, she took pity on his frustration and cleared the pachyderm walls for an outside view. He responded by pacing to the rear of the ship and stretching out on the bunk with his head propped up on one hand, staring out at the jungle.

Rahel poked through a clatter of sample slides at the station. She had to give Wels credit for not jabbering at her the way he had yesterday. He was a politician, after all, used to being able to change things whenever he wanted, make things happen, know whether or not he'd won a battle just by the climate in a room. Taking things at Nature's pace was well outside his range of experience. She wondered if she ought to suggest he go camping more often.

"How long before we go looking for it?"

Rahel glanced up from her marking. "We give it a chance to come looking for us first. If it still thinks it's a tiger, it's probably nocturnal anyway. And if it thinks it's Basa . . ." She turned back to the AI, suddenly embarrassed. "If it's Basa, it'll come back here looking for me. How else is it gonna get food?"

She heard Wels stir on the bed, mussing the covers. "Is that what we're going to call it?"

She looked over her shoulder to find him rolled over to face her. "Is what what we're going to call it?"

"Basa." He pushed up on his elbows. "We've got to call it something, and I haven't heard you suggest anything better." His shrug bounced the bunk more than him. "Why not call it a basa?"

Rahel surprised herself by blushing. "Sure." She nodded stiffly, not really wanting to talk about this right now. "Why not?"

Apparently sensing her discomfort in the discussion, Wels went back to watching the jungle, not talking again until long after sunset.

By that time, Rahel had entrenched herself far away from him in the cockpit, wearily eyeing the darkness for some sign of movement. She hoped nothing came—she hoped the basa was out somewhere bounding through underbrush and trampling marigolds.

The basa, however, seemed determined to disappoint them.

"Here it comes." Wels crawled to his knees on the bunk, both hands pressed to the wall display like a little boy with his first hologram. Rahel moved quietly up behind him, caught again by the illusion that silence was a necessity.

The basa trotted into the open and half-way around the clearing before some sound or memory seemed to confuse it and brought it to a stop. Whistling a puzzled, doggy sound of distress,

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it bounded to the outpost and danced to a stop in front of the closed hatchway door.

"Don't open it," Wels whispered, tapping his fingers on the display. "Please, don't open it."

Some infinitesimal adjustment rippled through the basa's muscles, and the eager, doglike brightness receded. Rocking upright, it manipulated the lock and pushed the heavy door inward. As it disappeared inside the building, a lonely, canine wail echoed through empty halls.

Rahel swore and kicked the side of the bunk.

"It didn't work." Wels sank onto his heels, his expression numb. "I don't understand. Why won't it take the jembel memories?"

Rahel scrubbed her hands through her hair, feeling stupid and slow and disgusted. "Because the basa's a predator, and the jembels are prey."

He twisted a startled look back at her. "What do you mean? That this thing only kills and eats other predators?"

She shook her head. "Just that it only remembers what it learns from other predators." God, it made so much sense, she could slap herself for not seeing it sooner. "Depending on how long these things hibernate, a lot of things can happen in their environment. If they wanted to find a successful niche real soon after coming out, they'd have to short-cut trial and error. So they munch a couple of whatever's currently the dominant predator, absorb what that predator knows about the current environment, and bang! Instant top of the food chain." She paced to the back of the pachyderm, drumming her hands against her thighs in thoughtful rhythm while the basa slunk away from the outpost to disappear, howling, into the trees. "They must go back to hunting prey after that, otherwise the jembels would take over and the basas would leave behind an environment with no predators when they went back into hibernation. It hit the tigers this time out because the tigers were the biggest predator around. Dammit!"

Wels scooted around to sit on the edge of the bunk. "If they only remember what predators tell them, then why do we have this problem to begin with? Tigers eat other animals, not people."

"Yeah, but the tiger this thing ate had already eaten Del Harbin. Remember?" She paced up into the cockpit. The whole pachyderm now seemed suddenly small and restrictive. "The basa may very well believe people are all the New Dallas predators eat nowadays." She paused at the front viewport, listening while the basa's wail faded with distance.

"Except?"

When she turned to scowl at him, Wels rose and walked halfway to the cockpit. "I hear an 'except' in your voice. What is it?"

A politician, she reminded herself. "People are predators, Wels. Only the thing we prey on the most is each other."

With people once more in the equation, Wels's leadership habit bubbled surfaceward again. "So unless we figure out how to stop it, this thing is going to go around looking for other humans to eat?"

"Seems likely, yeah."

"Well . . ." He clenched his teeth

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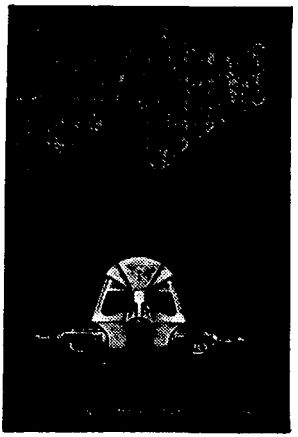

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and crossed his arms, straightening with sudden certainty. "Then I can think of one way to solve this right now."

Rahel leaned back against the console, unimpressed with his decisiveness. "We're not going to kill it."

He exploded into a sigh of frustration, slamming the heel of one hand against the testing station seat and sending it into a mad whirl.

"It was here first, Wels," she said, anticipating his next flurry of predictable, politician questions. "It owns New Dallas more than we do, and I'll be damned if I let you take the kind of liberties you're suggesting just because—"

"Dammit, Tovin, we're talking about *people* here!"

"We're talking about *animals!*" She shoved away from the console, down the steps, and into his face before he could do more than jerk back in surprise. "People are *animals*, just like anything else! We think we've got more rights just because we have a bigger brain case, but we're wrong! If anything, we gave up our rights to fair treatment when we killed the last passenger pigeon!"

He shook his head, concern carving a furrow between his elegant brows. "If you really believe that," he said, very quietly, "then you're less human than that thing out there."

"Yeah . . ." This coming from a man whose very profession formed a menagerie of all that was human and vile. "Yeah, maybe I am." And thank God for that.

She swung about and found his sleeping gear stuffed into one corner of the cockpit. Wels didn't catch it when she threw the bundle at him, but she slung his spare clothes after without even giving him time to gather the scattered bedding.

"What are you doing?" he cried, snatching a shirt out of the air.

Rahel muscled past him to fling open the hatch. Jungle stench flooded the pachyderm. "Get out."

He froze, his arms loaded with his belongings. "What?"

"Get out!"

"And go where?"

"I don't care." She lunged forward to grab him by the collar and haul him toward the hatch. "Into the outpost, into the jungle." He stumbled out when she pushed him, but somehow managed not to fall. "You're the human—you decide."

"Tovin . . ." He backed into the outpost's open hatchway. Not enough moonlight penetrated the canopy to truly light his features, but she could still see the pale smudge of his face and hair against the darker inside. "You know I respect Noah's Ark, and I respect you. But what you're doing here—it isn't right."

"We'll see." She slammed the hatch, checking by habit to make sure she didn't trip over Basa, then flushed with anger and grief when she remembered that no one else shared the pachyderm with her now. "Maybe it's time we animals started sticking together."

As soon as Wels had locked himself inside the mining outpost, Rahel powered up the pachyderm and lifted clear of Melissa Pass.

"Find me a signal for all the tags from New Dallas genetic set #8737.

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Show me subject locations on my flight map, and update every five minutes."

"OK."

She had to cover more than half the continent before she found a tiger demesne with no people within 100 kilometers. It wouldn't do to introduce another tiger who preferred eating something besides the jembels that clogged this entire continent. According to previous safaris, only six of the original signal tags still led to living tigers anyway, and one of those had been Arjuna. So she hunted out an aging female, well beyond cub-bearing years, and killed her quickly and neatly.

By the time she landed back at the outpost, the sun was tall above the canopy, and the inside of the pachyderm smelled strongly of tiger musk and blood.

Wels's voice answered sleepily from inside the outpost when she pounded on the door. "Who is it?"

Rahel snorted and kicked the bolted hatch. "Oh, for God's sake, open the door. If I were a basa, I'd have just let myself in."

A moment of silence, then Wels cracked the hatch to peer out at her. A wisp of cool air swirled between them. "You would not. I hard-locked the hatch from inside."

"Good for you." She pushed past him, scanning the interior for his gear. "Come on—we've got places to go, things to do." She wound up his bedding without asking, leaving him to grab his clothes.

Wels followed her into the daylight. "You're not taking me back to the Colony." It wasn't quite a question, but suspicion made it nearly so.

Rahel waited for him to dog the outpost hatch. "I'm not taking you back to the Colony."

"Then where are we going?"

She climbed into the pachyderm and pitched his things toward the bunk, letting them fall where they would. "Hunting."

Wels wrinkled his nose as he came through the hatch, but didn't say anything. Once he'd piled his own armload with the rest of his gear, Rahel sealed the door and waved him into the cockpit. The tiger lay stretched out between the testing station and the bunk. Even with her handling equipment, it had been a bitch getting the 100 kilo carcass inside.

"Find me New Dallas signal tag #B-1, and plot me a point on the flight map."

"OK."

Wels frowned as Rahel woke up the engines. "Off decimating the wildlife, I see."

"More like judicious pruning." She lifted above the treetops while keeping half an eye on the map. "Sometimes, a few have to die to preserve the whole."

He stared into her face for a long moment, the trail of his thoughts showing clearly in his eyes. "Are you actually planning to feed that thing another tiger?"

Her peace with this decision actually moved her to smile faintly. "I'll even feed it two, if I have to."

Wels jerked a look behind at the carcass, then back at her, eyes wide. "Dammit, Tovin, tigers are what started this problem! I don't see how feeding the basa more of the same is going to fix things."

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She grinned, looking ahead rather than at Wels. But she knew he could see her. "Of course you don't."

Wels settled into his seat, his chin coming up in that way Rahel could already recognize as his stubborn prelate mode. "Ms. Tovin, we brought you here to resolve this situation so that my people could continue to do their jobs in safety."

Rahel shook her head, grinning. "Wrong. You brought me here to evaluate an imbalance in your ecosystem that was making tigers eat your miners."

"What's the difference?"

She laughed. "A politician, of all people, should respect the importance of fine-line distinctions." When he only pursed his lips in reply, she said, "The difference, Prelate, is that I got tricked into thinking that what needed solving here was the danger to human life. And that was all wrong. What needed solving was the imbalance. All I'm bound to do is get the basa back to eating the wildlife—which we have every reason to believe a brief diet of tiger will take care of."

"Even if it means you'll leave an entire Colony in danger?" Anger prickled at the edges of his tone, the first hint Rahel had that he was beginning to understand.

"In a word?" She shrugged. "Yeah. The basas were here first, Wels. It's your job to get along with them, not the other way around. Stupid human arrogance is the only thing that makes you think otherwise."

Wels stared ahead at the jungle tumbling past below them. A trace of red stood out along the arch of each cheek, a legacy of the temper Rahel knew he thought himself too civilized to lose. "Noah's Ark won't let you do this."

"Don't count on that. The Ark exists to protect whatever we can of the big picture, not just single animal lives. How human beings fit into other worlds is part of that big picture. Humans took over Earth because a fluke of genetics gave them the ability to alter their environments. Well, the basa's an animal that a fluke of genetics has allowed to alter itself to suit its environment. If the tigers are going to survive here as predators, they're going to have to evolve to fit the basa's environment."

Wels nodded, very slowly, lips pressed tight with unhappiness. "And so are we."

Rahel glanced over at the flight map without answering, noting the slight movement in the basa's tag signal.

"You don't think we can make it work, do you?"

She studied Wels in silence, tried to imagine this coiffed and earringed dandy surrendering himself to the forces of natural selection. "Why should I?"

He laughed shortly, a darker, more cynical laugh than Rahel had heard from him before. "Because we really are better than simple animals, Ms. Tovin. We can think, we can change. We can do things because we want to, and not just because Nature forces us to."

"Can and do aren't the same things." Snapping free the buckles on her safety harness, Rahel slid out of her seat. "Hold us here," she told the AI. "I've got a delivery to make."

"OK."

Wels turned to watch her light-weight the tiger and drag it toward the hatch-

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way. "You don't know that the basa will eat it."

"I rubbed it down with dog food. It'll get hungry enough, trust me."

"And if it gets hungry enough for people?"

She wrenched open the hatch, shrugging. "You cope."

Wels stood and joined her, taking hold of the tiger's rear end to help her heave it out the door. Then, leaning out to watch the carcass crash through the foliage toward the waiting wildlife below, he laughed sourly. "At least, I hope we cope."

She pulled the hatch closed, sealing New Dallas alone with itself. "Yeah, Prelate, I hope you do, too."

Only time would tell. ■

●However a hypothetical civilization might achieve spaceflight, ours did so as an arbitrary consequence of international military competition. The scientists did not successfully agitate for rockets to loft their instruments above the atmosphere; the businessmen did not float into space on issues of interplanetary stocks and bonds; the general public did not rise up with one voice and shout: "Upward!" Instead, a coalition of fanatic spaceflight enthusiasts, beleaguered military agencies, and capricious political leaders focused enough effort to develop long range missiles using a technology that could be adapted to modest space projects. Whatever emphasis we place on each of these actors, the whole process was neither pretty nor inevitable.

Williams Sims Bainbridge,
in *Goals in Space* (State University
of New York Press)

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Amy Bechtel

STRANGER THINGS

When a doctor treats lots of species, he must expect surprises—but some get more than others.

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On Wednesday Howard Winston brought a box turtle to the clinic. I was relieved at first, because Howard has the most bizarre collection of animals you can imagine, and as his long suffering veterinarian I was glad to see nothing more exotic than a turtle in his arms. But even before he put the turtle on the exam table, he told me that there seemed to be something wrong with his sea monsters.

"What?" I said, horrified. "What's the matter with them?"

Howard glanced behind him to make sure the exam door was shut; he kept the existence of his sea monsters a closely guarded secret. He said, "I don't know, really. They're just not acting right."

"What do you mean, not acting right?"

"I don't know. I can't put my finger on anything in particular. They just don't seem themselves. Could you come and have a look at them sometime?"

I told him yes, of course, as my mind raced through everything that might possibly be wrong with a sea monster. Howard had taken care of the whole batch of little monsters after Nessie (the mother monster) died, and I was afraid that the little ones might have contracted the same disease that had killed Nessie. If so, I was in trouble, and so were the monsters, because I still didn't know what the disease was or how to treat it.

"So what do you think?" Howard said.

"I don't know," I said. "I'll have to see them."

"I mean about the turtle."

I had forgotten about the turtle. Howard carefully placed it on the exam table and stepped back.

"I think it's his leg," he said.

I looked thoughtfully at the turtle. From this viewpoint it appeared that the turtle had no legs at all. Or a head. I waited for a while, hoping the turtle would stick out an appendage but apparently it had settled into its shell for life. I picked it up and tried to peek into the crack between the top and bottom shell, but the turtle clamped shut even tighter and I couldn't see a thing. Trying to pry it open didn't work either. I gave up and put it back on the table.

"Which leg is it?" I asked Howard.

"That one." Howard pointed to the place where the right hind leg would be if it were there.

"Is it limping?"

"Sort of. More like dragging it. Since yesterday. What do think is wrong, doc?"

In spite of our long acquaintance, Howard still seems to think I am a miracle worker. I was saved from having to tell him I didn't have the foggiest by Kami, my brand-new receptionist, who knocked on the exam room door and breathlessly threw it open.

"Doctor Clayton," she said, "sir, there's a man with a *snake* here to see you."

I sighed. "Put them in the other room and I'll be right there."

"But doctor! It's a *snake!*"

"It's all right. I'm a vet. I treat snakes."

Kami gave me a dubious look and went back to the waiting room, shutting the door behind her. The turtle was still snug in its shell

"Your new girl seems a little confused," Howard said politely. "When

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I called for an appointment this morning she cut me off three times."

If that was happening to all my clients I was in trouble. "Sorry," I said feebly. "She was all I could find."

I told Howard to try to coax the turtle out of its shell while I was gone, and went to the other exam room. A man with a pillowcase was waiting for me.

"Something's wrong with my snake," he announced.

"What seems to be the problem?"

"Dunno. He's just not acting right."

I picked up the file to check the presenting complaint, which Kami had dutifully written down as "not acting right." It wasn't much help. There was nothing for it but to take a look at the snake. I took a deep breath and reached for the pillowcase, prepared to plunge my hand inside and grab the snake (and so demonstrate my confidence in handling snakes, though to tell the truth they give me the creeps.) I had my hand on the pillowcase when I heard a faint, ominous rattling noise. I took a hasty step back.

"Excuse me," I said, "but what sort of a snake do you have?"

"Why, he's a rattler."

"In a *pillowcase?*" My voice was starting to squeak.

The man looked puzzled. "Sure. I didn't want to just carry him."

"Of course not," I said, taking another step back. "But you see there is a problem. I don't treat rattlesnakes."

"Your receptionist said you did. I asked her specifically."

"Yes I know she did, and I'm terribly sorry, but she was mistaken. I simply don't treat poisonous snakes."

He glared at me and picked up his pillowcase, which was now hissing and rattling in quite a lively fashion. "Hell!" he said, "What kind of a vet are you?"

After he had stormed out, Kami hurried up to me, even though the phone was ringing off the hook and clients were lined up at the front desk.

"I thought you said you *treated* snakes," she said anxiously.

"Not *poisonous* ones," I said.

She stared at me, wide-eyed. "You mean they're not all poisonous?"

It was a blessed relief to get out of the office that afternoon. I left Kami instructions to answer the phone, make appointments for tomorrow, and refer emergencies to my colleagues; as I drove away from the office I tried not to think of the chaos that was bound to be the result.

It was a beautiful spring day, after all—wildflowers were blooming in the pastures and the sun was bright in the sky. I rolled down the truck windows, cranked up the radio, and took a deep breath of spring. The singer on the radio was warbling a twangy song about love; I sang along in a different key. It was three o'clock. Say an hour to reach Howard's place, an hour to examine the sea monsters, and an hour back; I'd easily be home by six. That would give me two hours of leeway to get ready for my date. I still couldn't believe it: I had finally gotten up the nerve to ask Susan Rose for a date. And she had said yes. I thought about Susan Rose all the way to Howard's, and the miles swept past almost unnoticed. I even managed to forget (mostly) about Kami.

Even the queasy hairpin turns and the

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mile of bumpy potholed wagon-track across Howard's property failed to bother me this time; I arrived at the sea monsters' pond in good spirits. Howard and Lynda were waiting for me. Lynda used to be my receptionist, until she moved in with Howard and took a leave of absence to study sea monsters. She used to be a *good* receptionist. I hadn't realized quite how good she was until Kami came along.

"So how is Kami working out?" Lynda asked cheerfully as I got out of the truck.

"Don't remind me of Kami," I said. "I nearly got killed today because of her."

"Poor Michael. Come and have a look at the monsters."

We sat on the bank of the pool and watched the monsters play. They had grown tremendously since the last time I had seen them and now all ten were at least as big as me. I was still able to pick out the one Lynda had named Curious. We were pretty sure that Curious was a male. It was hard to tell, though; the monsters still had *lots* of growing to do and were quite immature. The name Curious, at least, would fit either sex; it's not wise to give a thoroughly masculine and/or feminine name to anything until you're *sure*. I still give yearly vaccinations and physicals to a sweet little female cat named "Stud."

I had trouble telling the other monsters apart but Curious was a different story. His manatee-like face was more wrinkled than the others, his whiskers were longer, and there was *lots* more mischief in his bright little eyes. He splashed to the edge of the pond, lifted himself up on tentacled fins, and squeaked at me.

"Translation?" I said, glancing at Lynda.

"Don't rub it in," she said darkly. "You know perfectly well I haven't figured out their language yet."

"Don't see why not, after all this time. . . ."

Lynda threw a rock at me and I retreated to the edge of the pond. I knelt to greet Curious, who took hold of my hand with his tentacles. You'd think it would be like holding a handful of snakes but it's actually quite pleasant. "Hey, Curious," I said. He seemed fascinated by my hand, and I realized that I'd never before been in such a good mood when I'd been in contact with him. The one thing we knew about sea monster communication was that they could pick up strong emotions on contact; their squeaks and whistles remained baffling.

Curious let go, dove, and joined his brothers and sisters. They clustered in a circle, touching fins and whistling, then turning to cast quick glances in my direction. It was almost as if they were gossiping about my date with Susan Rose. Who knows—maybe they were.

There certainly didn't seem to be anything wrong with them. I watched their play with a critical eye; they were all obviously well fed and fit. They were sleek and active and they looked like perfectly healthy sea monsters to me. I watched them for a while longer. They still looked fine.

"I give up," I said at last. "I don't see anything wrong with them."

"They're acting normal right now," Howard said. "I guess they're excited because you're here. But doc, they're

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not usually like this any more. They're kind of lethargic."

"Lethargic? *Them?*"

"Well. Relatively speaking."

I looked at the sea monsters again. They were engaged in a very energetic game of splash and chase. It was difficult to imagine them lethargic, but Howard had a keen eye for his pets' behavior and I didn't doubt his word.

"I guess I'd better take some blood samples then," I said. I had been collecting blood from the monsters for months, compiling a range of normal monster data; if there was any change perhaps it would tell me something. I took samples from all of them, from the big vein that ran along the bottom of their four-pronged tails; they endured the needle pokes stoically and then returned to their game.

As I stowed away the blood samples Howard held up his turtle, which I had not yet diagnosed. It was still clamped tight in its shell.

"Watch him for a few days," I instructed. "If he keeps on limping we'll take an x-ray."

Howard nodded seriously, as if I had actually done something significant, and I crossed my fingers and hoped it would get better on its own; I was not at all sure how I planned to x-ray the leg when I couldn't even get a look at it. But as long as the problem was put off till after my date tonight, I didn't care.

"Want to stay for dinner, doc?" Howard suggested.

"Oh no. Thank you. Have to be going."

Lynda gave me a sharp look. "Aha," she said. "You have a *date*."

* * *

I was halfway home when the mobile phone began to bleep. I looked at it uneasily, hoping it would stop; I wasn't supposed to be getting any calls. I'd told Kami to refer all the emergencies away. *This* night I was taking off.

The phone did not relent; finally I picked it up. Kami's breathless crackly voice came over the line.

" . . . wasn't sure what to do," she said, "but Mr. Johnson said you were the only one who could help and the other doctor wouldn't do and his poor cow was going to have a baby and he said she'd die if you didn't come, so I told him you'd be right there."

"You told him *what?*" I suddenly felt very cold. It was six already and I *had* to be home before eight.

The phone crackled again. " . . . you'd be right there," Kami said.

I took a deep breath and counted to forty-five but I still wanted to throw things. Preferably at Kami. But it was too late now; I was stuck with seeing Mr. Johnson's cow regardless. I knew the Johnsons well; their place was on the way home. I'd lose no travel time. And it was only a calving; how long could it take? Surely I could still get home by seven. Plenty of time to shower and change clothes. "We'll talk about this in the morning," I said to Kami. "Now: lock up and go home. Do *not* answer the phone again. The answering service will answer the phone. Don't *touch* the phone."

I hung up and pushed the truck up to eighty. Thirty minutes later I was out in a pasture, trying to catch the Johnsons's cow.

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"She's a bit wild," Mr. Johnson had said, placidly chewing a lump of tobacco and looking a bit like a bovine himself. As was his custom he had pointed out the patient to me, and had then seated himself in the porch swing to watch. Tonight he was getting quite a show. I'm good at roping most of the time, but so far tonight I had caught only a fence post and a small tree. It didn't help that it was nearly dark and the cow was black.

It was a quarter to seven by the time I had the cow caught and tied. The second hand on my watch raced faster and faster as I lubed my hand, lifted the cow's tail, and stuck my arm into the vagina as far as it would go. I was hoping for a simple presentation but what I felt filled me with horror. The calf was enormous, edematous, and quite dead. There was no way in the world it was going to come out in the usual manner. I would have to do a fetotomy and deliver the calf one piece at a time.

I had hated fetotomies passionately ever since studying them in school—I'd once made the mistake of bringing my fetotomy book to the library, where I had made the acquaintance of a very lovely girl. I was all set to ask her for a date when she glanced at my book, turned green, and rushed away. I guess the color pictures illustrating how to saw apart a dead calf inside the uterus *were* a little graphic.

Fetotomies are horribly messy, as you might imagine, and they take a long time. You can't rush when you're working blind with a razor-sharp wire saw that can easily lop off your hand.

I finished at a quarter of eight. I untied the cow and staggered to my feet. Mr. Johnson, staying carefully upwind, approached me with his checkbook out; I said, "Never mind. I'll send you a bill," and leaped into the truck.

I made it home by five till eight, but Susan Rose was early.

"Hi," I said weakly.

"Hello," she said. She stared at me and took a step backward. God, she was stunning. She was wearing a low-cut dress and high heels and she might have been wearing perfume, though it was hard for me to tell. I was enveloped in the rich, pungent odors of urine and feces and birth fluid.

"Sorry," I said. "Sorry I'm late. But there was an emergency. But I can be ready in fifteen minutes, and won't you come in and wait?"

Susan Rose hesitated, then said, "Maybe, ah . . . maybe we should put this off till another day. I mean, you must be awfully tired." The wind changed, blowing in her direction, and she looked alarmed.

"Oh. Right," I said. "Certainly. Another time." I knew perfectly well that there wasn't going to be another time. I'd blown my only chance.

Susan Rose didn't run on the way back to her car, but that was probably because of the high heels.

I was going to give Kami a stiff lecture the next day, but she was so wide-eyed, attentive, and eager to please that I didn't have the heart. I made my way through the morning appointments, feeling desolate every time I saw a kitten (Susan Rose had a kitten). In the afternoon I got back the sea monsters' blood work from the lab. I took out the file of normal results and started com-

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paring. Most of the values were in the same range, but some were not. Lymphocyte counts were down, glucose was up, alkaline phosphatase was up. It didn't seem alarming, but it was strange. I dug out the blood work I had done on Curious after he'd undergone a long car ride and had almost dehydrated to death; it was disturbingly similar. In another species I'd call the changes a stress reaction. Could the sea monsters be under stress? It was hard to imagine how. Perhaps it was stress due to a rapid growth phase. Perhaps it was stress due to an underlying disease that I had not detected. Perhaps—

I would have to get a better look at what was going on with the monsters.

I hadn't been diving since Spring Break in Mexico almost ten years ago, and then I'd spent very little time in the water; I much preferred hanging out on the beach and watching the swimsuit styles. I wasn't looking forward to diving now but the monsters seemed thrilled. Howard hadn't been diving with them for quite a while—the last time had been months ago, when he'd set up artificial boundaries underwater and had impressed upon the monsters how dangerous it would be for them to go any farther. I still had nightmares about the time Curious had found his way through underwater passages and had surfaced in the Hubbingtons's stock pond. The Hubbingtons were avid hunters; if they'd seen him there he would probably now have his head mounted on their living-room wall.

All of the monsters dove with us as we swam deeper and deeper into the pond. The water was clear, which surprised me; I'd expected it to be murky, full of algae and mud like the typical stock pond. But this water was like crystal and I could see easily through my mask. The pond was much, much larger than I had imagined. Not far from the surface the rock walls receded into the distance and we found ourselves in a vast underground lake. I couldn't see the bottom; the water seemed to go on and on, endless. Howard had said he'd never found the bottom. We drifted toward one wall, which was honeycombed with holes leading into a watery labyrinth.

Slowly I swung in a circle, examining the lake carefully; in school I had always been taught to examine an animal's habitat as well as the animal itself. I suspect the professors had in mind bird cages and barns, but the theory would seem to apply here as well. Was there anything in the sea monsters' environment that might be causing stress or illness? I had no idea what they required, much less what they might not like, but stubbornly kept looking anyway. Sunlight filtered into the upper parts of the watery cavern; the lower levels were deep in shadow: a monster would be able to pick and choose any level of light it desired. Something brushed against my leg and I saw a silvery flash; when I looked closer I saw a whole school of tasty-looking fish swimming industriously by. Plenty of food, then, though who knew if these fish satisfied all dietary requirements of monsters? Could they be disturbed by their confinement, frustrated that they were not allowed to explore the labyrinth? Perhaps, but how could any monster feel confined in a lake so deep that

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no one had been able to find the bottom? Really, the place seemed an ideal habitat for a sea monster.

Curious suddenly swam past me and clasped Howard's hand, tugged him in the direction of one of the gaping holes in the wall. The other monsters stopped roughhousing and hovered near, watching us. One of them brushed against me tentatively and I felt a sudden overwhelming need to explore that passageway. Without thinking I followed Howard and Curious to the mouth of the passage. Curious held back, apparently too well conditioned to pass the artificial barricade, and Howard and I swam on.

The passage led deeper into the labyrinth. The rock walls were smooth and slick, shining bright in the light from our flashlights. As we swam farther the water seemed to become warmer and there was something luminescent growing on the walls, giving the entire passage a bluish glow. It looked so weird that I wondered if it was all a product of nitrogen narcosis—we were down below a hundred feet, and would soon reach what Howard called the three-martini level. I was about to grab Howard for reassurance when we came to a vast underwater chamber, all spectacularly lit with the blue luminescence. In the middle of the chamber was a creature.

And I had thought the sea monsters were strange.

In the blue glow the creature looked unearthly. It was enormous, far bigger than even Nessie had been, and it *flowed* as it moved. Rather than being spherical it was long, almost snakelike, but unlike a snake it was beautiful. It had a slender, elegant head, big limpid eyes, hundreds of fins with long flowing streamers sweeping behind them. It stopped and looked at us, straight at us, its streamers fanning around it like a huge cloud of hair.

It started to swim toward us and I panicked. I grabbed Howard and began to swim desperately back up the passage. Howard hung back but I dragged him with me; that thing was so huge that it could swim right over us and never even notice, and suppose it was the kind of creature that liked to defend its territory from strangers? The decompression stops on the way back up were terrifying. If I'd been alone I might have skipped them and ended up killing myself with the bends, but Howard was experienced at diving and forced me to wait the required times even as I'd forced him to start for the surface. It was a long time before we broke surface and crawled out onto the bank. I peeled off my mask and mouthpiece and sat for a moment just breathing the air. The monsters were whistling and squeaking at us, and Lynda was asking worried questions, but neither Howard nor I could speak for a while.

Howard finally said, "Went too deep, I think. Nitrogen narcosis."

"Yes," I said. "Hallucinations."

We both looked at the water, at the concerned-looking monsters clustered near the bank. The water rippled in a soft breeze, beautiful and calm and safe.

"What are you talking about?" Lynda said. "What did you see?"

"Nothing," I said. "Just hallucinations. Can't really have been anything there."

"No," Howard said. "No, of course not, nothing *that* big could live down

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there."

"Of course it couldn't."

But we'd seen exactly the same thing and we both knew that it was really down there, that beautiful, extraordinary creature that had looked us both in the eyes and—

I'd seen that look before. On a trusting dog that seemed to know that I was trying to help when I put a splint onto a painful leg. On a cat with a fishhook caught in its lip. Even on the broken-legged orphan calf that I'd wished on Howard.

The look said *help me*.

I couldn't stop thinking of the creature in the labyrinth under the pond, of the look in its eyes. Even while I was trying to figure out how to x-ray Howard's turtle I was still thinking of the creature. I'd never imagined that anything so strange could be so overwhelmingly beautiful. Had Nessie the sea monster known this creature? Had they been friends of a sort? Or had they been mortal enemies, desperately defending their territories and—

"Mr. Winston is here," Kami said. "He brought Hercules."

"He brought who?"

"The turtle."

"Oh. Of course." I still hadn't figured out how I was going to x-ray that blasted turtle and the moment of truth had arrived; I was going to *have* to stop distracting myself with thoughts of underwater creatures. I went in to see Howard, who had Hercules cradled in his arms.

"He's still limping," Howard announced. "I brought him for his x-ray."

The turtle looked just the same to me: a smooth solid shell with no appendages. Why couldn't turtles be a little more cooperative?

"Right," I said, stalling for time. "And how are the monsters?"

"They're not any better, doc. They still seem all *distressed* about something. I wondered if it might have something to do with that—well, with what we saw. Whatever it was."

I thought about that: maybe the monsters were afraid of the thing. But no, that didn't make sense; Curious had guided us to the passage and had seemed eager for us to go in. Maybe the little monsters were afraid *for* it. Or maybe they were picking up fear *from* it. Only why would something so big be afraid, especially when it had such a safe, secret place in which to hide?

"Safe," I said suddenly, looking at the turtle.

"Excuse me?" Howard said.

"Just a second. I have to go find a box."

The syringe box was just the right size. I dumped the syringes onto the pharmacy counter, scooped up the box, and took both box and turtle into the x-ray room. I placed the turtle on the x-ray table, covered it with the cardboard box, and turned out the lights. Fifteen minutes later I took an x-ray, box and all; in the darkness of the box Hercules had felt safe enough to extend his head and legs. There was nothing broken, thank God—I don't know what I'd have done if there had been; you can't just slap a cast on a turtle's leg.

"So what do you think?" Howard said.

"Oh, a sprain or a bruise I suppose.

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Hercules should be fine; just give him time."

"I mean about the monsters."

I had been trying very hard to forget about the monsters.

The next time I went to Howard's place, the change in the monsters was obvious. They'd all lost weight and they weren't playing; they were swimming idly or merely floating near the surface. Howard was scared; Nessie and her mate had died of something insidious, and the main symptom had been weight loss. But Lynda, who'd attempted communication with them the most, didn't think they were sick. She thought they were picking up distress from whatever was down below. Remembering the look in the creature's eyes, I had to admit the possibility. I had to at least take a look at the creature.

This time, knowing what lay ahead, I found the dive even more frightening. But the monsters were *happy*. They circled around us with eager enthusiasm, guiding us to the passage we'd taken before, and this time the invisible barricade didn't stop them. They hesitated at the opening, as if bracing themselves, and swam on. Howard and I followed.

We found the creature floating limply in its vast bluish cavern. It turned its head to look at us, but didn't move, and its eyes looked glazed: it looked as if it had given up on life. There was no question, now, that there was something wrong with it; over only a few days its condition had deteriorated drastically. With the little monsters hovering nearby, worried looks on their wrinkled faces, I found that I was no longer afraid of the creature. I swam to it and began my examination.

I started the exam mechanically, without any real hope of figuring out what was wrong with such an outlandish creature, but as I worked my way from the head to the neck to the undulating snakelike body, I found the problem.

The creature was female, she was an egg-layer, and she was egg-bound. She must have been trying to deliver this egg for days and it was firmly, solidly stuck.

Her body twisted and she swung her head all the way round, so that it was only inches from my face. She pushed at the egg with her snout, futilely, and then looked at me.

I took a deep breath, trying to think what to do. It would be easiest, perhaps, to break apart the egg as if it were a dead calf and deliver it in pieces, but somehow I didn't think that the creature (with its huge mouth so close to me) would approve of that. Besides, whatever was in the egg might still be alive. It was going to have to come out in one piece.

I wanted to swim back up and read some books but that would take forever, and would probably be unhelpful at best; I would simply have to extrapolate from what little I knew about egg-bound birds and snakes. What was supposed to help the egg-bound patient? Increased environmental temperature, but that was impossible here. Lubrication—I had no lube with me and didn't think it would work well under water anyway. Traction and persistence—that I could manage.

But I was sorry I had ever complained about having to work in a pitch-black field by the dim glow of a pickup's

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headlights.

And removing the egg appeared to be impossible, even ridiculous, like attempting to thread a thick rope through the eye of a sewing needle. I couldn't even slip a finger between the egg and the body wall, and everything seemed terribly swollen (though it was hard to tell for sure; I didn't know what was normal). It didn't help that the creature kept her head swiveled in my direction, her nose almost touching my face, and that when she opened her mouth she revealed some decidedly formidable fangs. I kept working at the egg, stubbornly trying to fit it through the too-small passage, until I got cramps in all my fingers and had to stop for long enough to rest them and take a decent breath.

A tentacle touched me on the shoulder and I started, convinced for a frantic instant that the creature, displeased with my ability, had decided to eat me. But it was only Curious, looking over my shoulder. Apparently he'd been watching my efforts the whole time I'd been working. He gave me a quizzical look and swam over my head, coming to rest against the creature's side. He brushed his tentacled fluke across the bulge of the trapped egg.

I was about to chase him out of the way when I saw him slide a delicate tentacle between the egg and the body wall. The egg shifted fractionally and the creature closed her eyes, as if the movement hurt. But the egg was *moving*. Curious stopped and looked at me for reassurance, and I touched him quickly, hoping he'd understand the strong emotion of *yes*, and carefully guided the placement of his fin and tentacles, which fit into places my hand simply could not go. Together we delivered the egg.

Curious backed away in a flurry of fins and I was left holding the egg. It was an enormous, bulky thing, speckled purple in the dim blue light. The creature swung her whole body around to face me and waved a group of streamers in my direction. I've learned from painful experience not to get between a mother and her baby, especially if the mother is bigger than me and has fangs, horns, or claws. I handed over the egg.

She held it in front of her for a moment, rubbing her head against it gently, and her enormous eyes slowly closed, giving her an air of sadness and resignation. As if there was nothing alive in the egg after all. Slowly she sank, the egg cradled in her streamers, and vanished into the hazy depths like a mirage. I was left alone with Howard and a crowd of monsters in an underwater cavern that suddenly seemed echoingly empty.

After a moment, Curious swam after her.

The next day I got a call from Mr. Johnson. Apparently he had gotten hold of an orphan calf and had tried to give it to his bereft cow. She had responded by knocking the calf through a fence and trying to trample it. When I got to the farm the calf was lying in a heap just outside the fence, bawling, and the cow was at the edge of her enclosure, pawing at the ground and snorting as if ready to attack. I looked the calf over; it was shaken and bruised but appeared to be in one piece.

"I thought the old girl would be

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happy with another little 'un," Mr. Johnson said contritely.

"I'm afraid not, Mr. Johnson. Cows just won't accept a calf that isn't their own. The only way you can get them to take on an orphan is to fool them into thinking it *is* theirs. If you'd gotten a newborn calf immediately after she'd lost hers, and put the dead calf's scent on it, it might have worked. But not now. It's too late."

"Well, what'll I do with this here calf then?"

I looked at Mr. Johnson and sighed. He was old and frail and obviously was not up to bottle-feeding an orphan day and night. Besides, Howard owed me a favor, and it had been months since I had dumped an orphan calf on him.

"I'll find a home for it, Mr. Johnson," I said, and scooped it up and put it in the truck. As I drove back to the clinic I thought about the cow, wondering if she knew what she had lost. Had she known she was delivering a baby? Did she know that it had died? From the blank confusion in her eyes it seemed she had no idea, but who knew?

I remembered, suddenly, the way the underwater creature had bowed her head against her egg and slowly closed her eyes. *She* had known. Oh yes, she had known.

When I got back to the clinic Howard was on the phone.

"It's wonderful," he said. "The monsters are back to themselves, 100 percent. It's as if nothing was ever wrong. And they keep going off for long periods, especially Curious—I think they're visiting her."

"Maybe she'll adopt them," I said.

"Maybe! You'll have to come by soon. We'll dive again and have a look."

"Sure thing," I said. "And I'll bring you a surprise."

"You'll bring me a *what?*" Howard said, but I hung up before he could ask me any more questions and patted the calf on the head. It licked me with its big slobbery tongue and I remembered that until I got it to Howard's, I was the lucky soul who got to bottle-feed it. I found a clean calf bottle and poured in powdered formula (which dusted in the air and got all over my face), mixed it with warm water and put the top on. While I was busy shaking it into suspension the calf wandered off, apparently having decided that I was taking too long with dinner and that it was time to look elsewhere. I chased after it, bottle in hand; I found it in the waiting room, nosing through the plants.

"Doctor," Kami said, worried, "there's a *cow* loose."

"Yes, Kami. I'll take care of it."

I pulled the calf out of a philodendron and started across the floor, but I didn't see the puddle of urine the calf had left behind and the floor was awfully slippery. When I fell I dropped the bottle, and of course the lid came off, and I ended up in a heap with the calf on top of me and formula all over everything.

And Susan Rose walked in, with her kitten.

She was very polite. She didn't even ask why I was sitting in a puddle of urine with globs of calf formula dripping off my elbows. And I guess I figured I didn't have anything to lose: I asked her for another date.

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She said yes. Stranger things have happened, I suppose, but right then I couldn't think of anything more unlikely and amazing than that *yes*. ■

ANALOG'S NEW HOME

By now you've probably heard that *Analog* is no longer being published by Davis Publications, Inc. After a happy association of almost 12 years, we have been acquired (along with *Isaac Asimov's Science Fiction Magazine, Ellery Queen's Mystery Magazine* and *Alfred Hitchcock's Mystery Magazine*) by Bantam Doubleday Dell Publishing Group, Inc. These four magazines will henceforth be known as the Dell Magazines Fiction Group, under the direction of president and publisher Chris Haas-Heye.

It seems appropriate to tell you, the readers, what's going on; but the most important fact is that for you and our writers and artists the change will be hardly noticeable. The editorial staffs of all four magazines remain intact—we're even staying in the same offices for the time being—and BDD has an expressed commitment to maintaining the magazines' editorial integrity and the continuity of their subscription service.

Some of the names in the front of the magazines will change, but *Analog* will remain *Analog*. The same people will be trying as hard as ever to bring you the most stimulating mix of entertaining fiction and frontier fact available anywhere. If you want to write to us about how we're doing, we'll be as interested as ever in hearing from you. If you wish to submit stories or articles, our editorial interests and policies are unchanged. For now, you can even write to the same address you've been using; if and when that changes, we'll make sure you know. In other words your magazine will go on, and we hope you'll continue to enjoy and interact with it, very much as if nothing had changed.

We are grateful to Joel Davis for providing a congenial home and energetic support for *Analog* over the last decade and more—and now we look forward to a long and exciting relationship with our new "family."

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Martyn J. Fogg

WORLDS IN DARKNESS: PLANETS BETWEEN THE STARS

INTRODUCTION

Science fiction is full of bizarre planetary settings for adventures. Ordinarily Earth-like worlds are often not enough to satisfy a writer's creative urge. For extremes of environment we get "desert planets," "ocean planets," "ice planets," etc. Spectacular lighting effects are served up by having the planet orbit a binary star, or by placing it in the middle of a dense star cluster. Then there's the "rapid rotator," spinning so fast that the planet takes on the shape of an eccentric oblate spheroid giving a marked difference in gravity between equator and poles. A really weird one is the binary planet, where two worlds orbit each other so closely that they share the same atmosphere, allowing airplanes to conduct interplanetary travel!

The list goes on and, unless the author voluntarily constrains his world building to within the bounds of the laws of nature, seems limited only by the human imagination. SF writers are often in the lead when it comes to the imagination, but not always. For instance, take this quote, "*There must be numbers of runaway planets in interstellar space, joining a host of independent dark little suns and planets which were never bound to any star. If planets can have originated in the vicinity of a sun, there is no valid reason why these small bodies could not have originated independently, without being gravitationally attached to a larger body.*" This was written in 1963 by the well-known astronomer Ernst Opik, in a paper that was one of the first to address the question of the existence of planets outside planetary systems. Is it possible that many planets are solitary, wandering unaccompanied the depths of interstellar space?

In this article we're going to see what modern astronomy can say concerning the existence of *Interstellar Planets* (ISPs). How would they form? How

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abundant are they? How close is the nearest one to our Sun? How could we detect them? Of what use would they be to a space-faring civilization, or to science fiction authors?

SINGULAR AND UNBOUND PLANETS

Opik hinted at the existence of two types of interstellar planets: those that form as a solitary aggregate, in a similar fashion to a star; or those that form within a planetary system and are subsequently ejected. In two recent papers concerning the formation of ISPs, I invented a classification in which the former type are called *Singular Planets* (SPs) and the latter, *Unbound Planets* (UBPs). Let's look at both in that order.

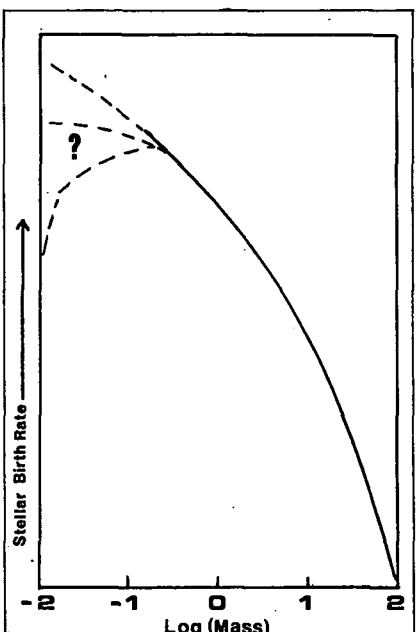

Figure 1: The stellar initial mass spectrum. The number of stars born in molecular clouds increases with decreasing stellar mass.

SINGULAR PLANETS

It may be that singular planets share their formation process in common with stars that are thought to form by a process of bulk hydrodynamic collapse of interstellar gas clouds. As the collapse proceeds, a cloud undergoes a process of hierarchical fragmentation, breaking up into smaller sub-clouds which then collapse and fragment independently. Only after several generations of this fragmentation does a sub-cloud become small and dense enough to contract to form a star. One of the most interesting things about this process is that it seems to favor the formation of low mass stars. This is why we observe a distribution, the stellar initial mass spectrum, where the number of stars formed rises rapidly with decreasing mass. Figure 1 is a rough sketch of the stellar initial mass spectrum, the slope of which is reasonably well established down to masses about a tenth that of the Sun (0.1 M_o). However, stars of this mass and less are very difficult to spot and so, as the diagram shows, we have very little idea as to whether or not the stellar mass spectrum continues to increase down to lower masses. If it does, then the Universe could be crowded with unseen dim stars and singular planets.

There is certainly indirect evidence for mass of some kind that we can't see that has a gravitational effect on the stars we can. Studies of stellar motions

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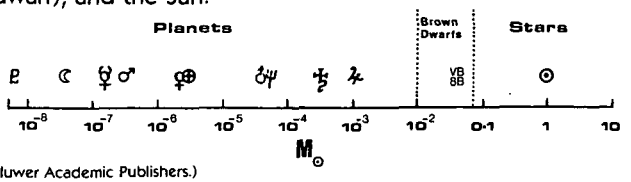
in the solar neighborhood suggest that about half of the mass in the area is unseen or "missing." The principal contender for the explanation as to what this missing mass is made of is a population of near invisible, low mass, stars. Stars like the Sun shine because of the fusion energy released in their interiors; however, fusion in low mass stars is very slow, which accounts for their low luminosities. Hydrogen fusion ceases to be sustainable at all in stars of less than 8% the mass of the Sun's (0.08 M_0), about 80 Jupiters. Such objects are called *Brown Dwarfs* and it is debatable whether they should be called stars at all. A brown dwarf would shine like a star early on after its formation as it radiates away gravitational energy of contraction and energy from fusion of deuterium and light metals such as lithium and beryllium. Thereafter it would cool into obscurity and darkness. If the stellar mass function were to continue into the brown dwarf range with the same slope, then Italian astrophysicists D'Antona and Mazzitelli have calculated that the missing mass can be accounted for by a population of 11 brown dwarfs per cubic parsec. By comparison, the number density of observed stars is about 0.1 per cubic parsec. This implies that if brown dwarfs exist, then the nearest one to the Earth could be less than a light-year away.

However, in this article we are interested in *interstellar planets*. I think you will agree that brown dwarfs have more of the characteristics of failed *stars* —warm globes of hydrogen and helium, weighing in at several Jupiter masses, that never quite started burning—rather than the planets with which we are familiar. However, it would not do to call a brown dwarf of Earth mass (if one were possible) a star, and so we will have to adopt a mass range in which we define an object as being planetary as opposed to stellar. There is some theory that can guide our choice, for it turns out that brown dwarfs may have a natural minimum mass. For some time, astrophysicists studying star formation have tried to pin down a theoretical lower limit to the mass of a star. They found that gas cloud fragmentation ceases when the collapsing cloud becomes opaque and starts to heat up. The minimum mass of cloud fragment appears to lie between 0.01 M_0 and 0.02 M_0. Thus we can define brown dwarfs as lying in the mass bracket 0.01-0.08 M_0, stars being more massive and planets less (see Figure 2).

Figure 2: The mass range of stars, brown dwarfs and planets. From left to right, the symbols represent Pluto, the Moon, Mercury, Mars, Venus, the Earth, Uranus, Neptune, Saturn, Jupiter, VB8B (a hypothesized but possibly spurious brown dwarf), and the Sun.



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What scope does this give for the occurrence of interstellar planets? If the stellar mass function is cut off at 0.01 M_o, then singular planets that form in an identical manner to stars seem to be ruled out. If current thinking in astronomy is correct, then the top-down approach to forming SPs, as a natural downward progression from the aggregates that form stars, may thus not be valid. Of course, our best theories to date could be wrong, so it remains possible, although less likely than Opik once thought, that collapsing gas clouds give birth to isolated planets as well as stars.

Another way singular planets might be formed is if such objects can be built up from smaller units rather than as fragmentations of a larger body. One object which might just be big enough to be called planetary and which some suggest may be able to form on its own within an interstellar cloud, is a giant comet, otherwise known as a "*plomet*." The origin of comets is an unsolved problem, although the majority of opinion favors their birthplace being the outer regions of solar systems. However, British astronomers Victor Clube and Bill Napier have for some time been prominent advocates of the hypothesis of an interstellar origin of comets. They propose that comets are formed within molecular clouds by the sedimentation of dust driven by radiation pressure from nearby hot, blue stars. Noting that the Sun's cometary Oort cloud is unstable over time scales of a billion years or more, they propose that it is continually replenished with swarms of captured comets each time the Sun, in its passage around the galaxy, passes through a molecular cloud. The interesting thing about the Clube/Napier theory for us is that they predict that some of these comets might be as massive as 10^{22} kg, similar to the planet Pluto. Moreover, there could be many thousands or so of these plomets per cubic parsec without violating any obvious astrophysical constraints.

However, once again this theory is not accepted by the majority of astronomers and so it may also be relegated to the "possible, but not likely" category. It seems that the prospect of the existence of abundant singular planets is not good, their formation requiring the most favored hypotheses of star and planetary formation to be wrong. The situation for unbound planets, though, is quite different.

UNBOUND PLANETS

In my classification, I split UBPs into two groups, *Late Type* UBPs and *Early Type* UBPs. The former involves the ejection of planets from mature solar systems, and the latter the loss of protoplanets from solar systems in formation.

Late Type UBPs.

I identified two planetary unbinding mechanisms that might produce late-type UBPs—namely supernova of the central star and close stellar encounters. (Any more suggestions are welcome).

When a star explodes as a supernova it ejects a substantial fraction of its mass as a high speed blast wave. From the point of view of an orbiting planet, this loss is instantaneous and, if it amounts

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to more than half the star's mass, planets will find themselves at above escape velocity and will be lost. Supernova explosion is the normal fate of heavy stars, more than about 4-8 M_o, and so a lot of mass must be shed. But since the remnant of such a cataclysm would be a neutron star of less than 2 M_o, it appears that the shedding of a planetary system is almost inevitable. Are massive stars likely to have planetary systems? It used to be thought that this might not be the case as stars heavier than spectral class F5 (about 1.3 M_o) are observed to rotate very rapidly, possessing as much angular momentum as our Sun and its planetary system combined. Thus the hypothesis was advanced that only low mass stars, which usually rotate slowly, possess planetary systems. However observations of very young stars show that all are born rotating rapidly and that they progressively lose angular momentum with age. Heavy stars, therefore, are always seen to spin fast because they have such brief life spans and not necessarily because of the lack of any planetary system.

Thus there is no known reason why planets should not form about high mass stars, although since such stars are very short lived, any planets would still be in a primitive state when ejected. Contrary to what you might think, all but the smallest planets could probably survive the awesome violence of a supernova explosion. Sure enough, the atmospheres of terrestrial planets would be blown away, and so might the upper few kilometers of crust, but the main bulk of the planet would remain intact. Being young, such a world may retain deeply buried volatiles which would be gradually outgassed and frozen onto the surface during the eons of wandering through interstellar space that would follow.

Having an estimate of the abundance of supernova-produced UBPs is much easier than trying to put a figure on any of the vague speculations concerning SPs. The stellar initial mass spectrum gives us the fraction of stars of all masses formed that will ultimately explode. If this fate is reserved for stars of more than 8 M_o, then a mere 0.2% of stars born will end their lives by going supernova. If stars of more than 4 M_o explode, then the fraction is five times higher at 1%. Assuming 30% of stars have planetary systems of an average of 10 planets each, then the number density of supernova-produced UBPs is between 0.0006 and 0.003 per cubic parsec. This type of unbound planet is thus likely to be comparatively rare, the nearest one to the Sun being 14 to 24 light-years away.

We'll look now at close stellar encounters and see how this compares. The Milky Way contains some hundred billion stars all traveling in independent orbits about the galactic center. The distances between the stars are so enormous compared with stellar diameters that collisions will have been extremely uncommon. But near misses where the stars ended up flying through each other's planetary systems would have been more frequent, especially in the crowded inner regions of the Galaxy. In this situation, planets might find themselves gravitationally perturbed by the intruder star into an escape orbit. They

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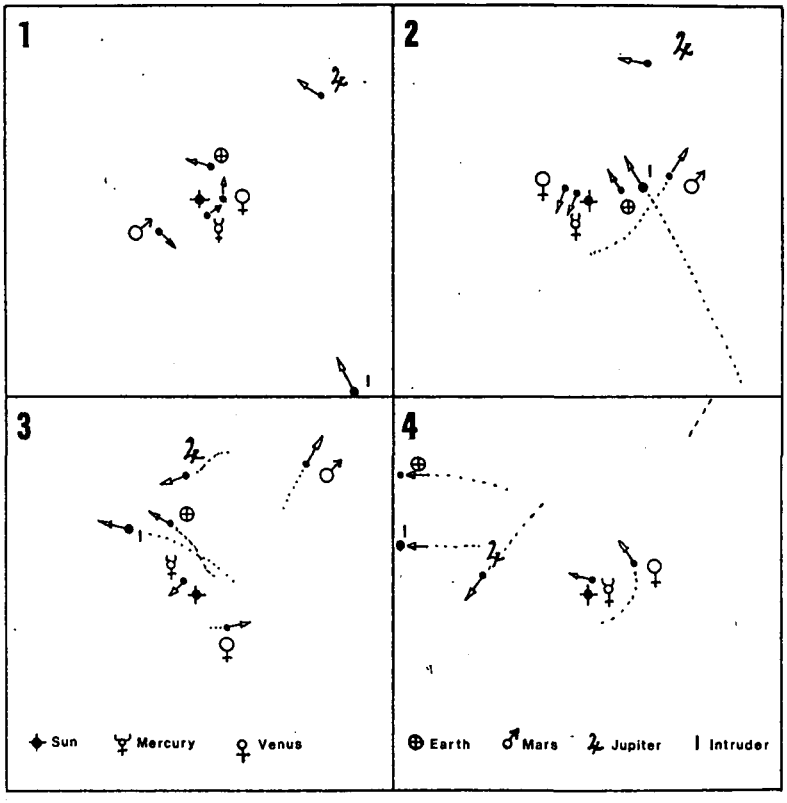
Figure 3: A simulation of the passage of an intruder star passing through the inner Solar System.



would become *unbound planets*. As an example of this process, Figure 3 shows sketches of four frames from a 2D simulation of close stellar encounters that operates on my home computer. The Sun is fixed at the center of each frame and is orbited by all the Solar System planets out to Jupiter. In Frame 1, a foreign star of 0.8 M_o enters near the bottom right at a distance of 10 astronomical units (AU) with a velocity of 35 km/sec on a course that will swing it past the Sun with a closest approach (the impact parameter) of 1.35 AU.This is a little closer to the Sun than the orbit of Mars. The orbits of the planets at this juncture are little affected.

In Frame 2, we see the rapidly accelerating intruder has sped into the inner Solar System and is almost at closest

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approach. Its brief proximity to Mars has been sufficient to wrench the planet from its orbit, catapulting it out into the asteroid belt.

In Frame 3, the damage really becomes apparent! Mars is well above solar escape velocity and is heading, with great haste, for interstellar space. The Earth has also been torn from its orbit and appears to be following the intruder on its way out of the Solar System. Something odd has happened to Jupiter: its velocity has substantially increased and its distance from the Sun has dropped by 1 AU. Venus has problems too, as it appears to be climbing out of its orbit.

In Frame 4, we have lost track of Mars. Jupiter has also just reached escape velocity, and has become an unbound planet. In ten thousand years or so it will have penetrated the outer bounds of the Oort cloud and have left the Solar System for good. Meanwhile, a peculiar fate has befallen the Earth: it has become captured by the intruder, stolen from the Sun into a frigid, lifeless orbit! Venus has escaped unbinding or capture, but is still seriously affected. Its orbit is now highly eccentric with a semi-major axis of about 1.2 AU. The only planet to have survived this disaster more or less unscathed is Mercury, a world that is so tightly bound to the Sun that an even closer encounter would have been required to fling it into the abyss.

If we had simulated the entire Solar System, including all the planets from Saturn outwards, it is likely that most of these remote worlds would also have become unbound. However, a "flat" simulation, such as described above, can only be of an illustrative use. To assess the effectiveness of close stellar encounters at producing UBPs, we would need to gather statistics from a 3D simulation, run many times over a wide range of inclinations and impact parameters.

In 1981, Los Alamos astronomer J. G. Hills published the results of his computer simulations of an encounter between a 1 M_o star/planet system and a 1 M_o intruder. He had performed several thousand runs using a wide range of initial conditions and subjected the resultant mass of data to statistical investigation. He came to the general conclusion that if the closest approach of the intruder is two to three times the orbital radius of the planet, then the encounter tended to expand the orbit, or dissociate it altogether. Hills then went on to estimate the likelihood of such an encounter disrupting the Solar System. Fortunately, it turns out that stars in our region of the Galaxy are so spread out that it is not likely that any foreign star has approached the Sun at a distance of much less than 980 AU over the entire 4.6 billion year history of the Solar System. An encounter with an impact parameter of less than 40 AU would probably have left some obvious mark on the orbits of the outer planets. The chance of this is only about $(40/980)^2 \sim 0.17\%$. It is therefore not surprising that the orbits of the outer planets (barring the enigmatic Pluto) are close to circular. The chance of the occurrence of a total disaster, such as illustrated in Figure 3, is a tiny $(1.35/980)^2 \sim 0.0002\%$. This is fortunate for us, but

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does not seem to hold out much hope for the production of abundant unbound planets in the solar neighborhood.

In my papers, I expanded on Hills's conclusions and calculated the flux of UBPs produced in different regions of the galactic plane. Where the Sun is located, about 27,000 light-years from the galactic center, my best estimate for the number density of stellar encounter produced UBPs was between 0.000042 and 0.00017 per cubic parsec, giving the nearest such world to be 35-60 light-years away. Thus, unbound planets of this type are likely to be even rarer than those produced by supernova ejection, except in regions of very high star density. Less than 3,000 light-years from the galactic center, the increasing proximity of stars to each other results in the encounter mechanism dominating over the supernova mechanism. In truly exotic locales, such as galactic cores and globular clusters, stars are so closely packed and close encounters so common, that planets, if they form at all will be snatched from their birth places and cast adrift. Unbound planets would wander interstellar space in profusion.

Early Type UBPs

A potentially rich source of unbound planets are planetary systems in formation about young stars.

Although a fully rigorous theory of planetary system formation that is capable of explaining all the features of our Solar System does not yet exist, there seems to be some agreement on the general course of events amongst the majority of astronomers. What we shall do now is to outline this standard scenario of planet formation to see if it also predicts the creation of unbound planets.

Our story starts with a newly created star, surrounded by a swirling and rotating cloud of dust and gas. Interactions between the dust particles cause their orbits to collapse into the mid-plane of the system to form a disc with the Sun at the center. This sheet of dust, however, is not stable. It clumps and coagulates under its own self-gravity to form a vast swarm of about 1 km wide rocky bodies called planetesimals. At this stage our Solar System would have resembled a vast asteroid belt. This setup is not stable either. Planetesimals in intersecting orbits can collide and, if their approach velocity is not too high, they will merge, resulting in a bigger planetesimal and a more circular orbit. In contrast, gravitational interactions between planetesimals, produced by near misses, serve to stir up their orbits, making them more eccentric and increasing the likelihood of a later collision. The evolution of a planetesimal swarm is a sophisticated problem that can be handled with modern mainframe computers and, although not all simulations of the process agree, many of the most recent ones suggest that planetary accumulation is a highly uneven affair. It appears, purely by chance, that those planetesimals that reach a certain mass undergo a runaway accretion process in which they rapidly sweep up most of the smaller bodies in their feeding zones. A lane is swept clear in the disc and a planetary embryo comes into being. In the colder regions of the nebula, rock/ice embryos of a few Earth masses now have sufficient gravitational potential to

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capture and hold onto hydrogen gas. This leads to another runaway—the rapid formation of Jupiter and Saturn which grow in mass by over an order of magnitude in less than a million years. This is a very important step, as the appearance of these two giants completely alters the nature of the evolution of the remaining swarm. Their gravitational fields are now so powerful that the great majority of approaching planetesimals which do not collide are scattered and flung out of the Solar System. The dominant process within the disc now is not accretion, but ejection. Some of these ejected bodies might have been big enough to qualify as unbound planets.

That's the scenario, but for significant quantities of UBPs to be produced by a by-product of planetary formation, the number of massive planetary embryos created during the runaway accretion phase must exceed the final number of planets. Is there any evidence, in the case of the Solar System, that this was so? Of course, direct evidence would require a time machine, but it turns out that a good deal of indirect evidence is at hand. It is becoming increasingly clear that the final stages of the formation of the Solar System were characterized by interactions between the newly formed planets themselves involving titanic clashes where entire worlds were in collision. For instance, the peculiar features of the Earth-Moon system are best explained by the hypothesis that our satellite formed from the debris of an off-center collision between the Earth and another young planet with the mass of Mars. The enormous iron core of Mercury, totally out of proportion with the planet as a whole, can be accounted for by an impact with another planet which blasted away most of Mercury's mantle. It is even possible that the peculiar retrograde rotation of Venus and the difference in elevation between Mars's Northern and Southern hemispheres can be explained by giant impacts. Surely, such huge impacts would be incredibly rare, I hear you ask. Indeed, this was an early objection to the impact origin of the Moon hypothesis when it was first suggested. Basing a theory on a highly unlikely random event always attracts criticism and rightly so. However, it is now becoming clear that planetary accretion will produce too many large embryos in intersecting orbits. In the final stages of the process, giant impacts may thus be the rule, rather than the exception. A glance at some of the simulations of the accretion of the terrestrial planets performed by George Wetherill of the Carnegie Institution of Washington shows this to be the case. Midway through the evolution of a typical swarm, about 100 bodies of lunar mass are in existence, along with 10 Mercury mass planets and a few as heavy as Mars. By the time the simulation has terminated, producing something like the inner Solar System, all the planets have been through a history of giant impacts. The enormous smash that created the Earth's Moon therefore may only have been the last in a line of them.

What's this got to do with unbound planets? Well, when worlds collide they can also be lost. In Wetherill's simulations, the conservation of mass was not

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perfect. Typically, about 5% of the mass of the swarm was perturbed into Jupiter crossing orbits. As mentioned above, most objects encountering this giant receive a gravitational slingshot propelling them on a one-way trip to interstellar space. The mass loss would preferably have been in small bodies, implying that up to eight Moon-sized UBPs could have been produced as a by-product of the accretion of the terrestrial planets. Unbound planets up to Mars's size would have been less likely but still possible.

In the outer Solar System, where orbits are less tightly bound to the Sun, the conservation of mass within any given zone would have been less efficient, and the size of planetary embryos significantly greater. In fact, paradoxically, it turns out that to explain the enormous masses of Jupiter and Saturn one has to postulate the ejection of an enormous mass excess from the Solar System. This is because of a process which I neglected to mention in my previous summary of planetary system formation, namely the T-Tauri phase of the Sun. Many protostars that we are able to observe (the star T-Tauri being the archetype), which are about a million years old, appear to undergo enormous eruptions during the final phases of gravitational contraction. This produces a powerful stellar wind that sweeps away and disperses the gas of the surrounding nebula. Thus, for Jupiter and Saturn to capture their hydrogen envelopes, they must have formed their cores in less than a million years. The problem with this is that minimum mass models of the pre-planetary nebula, those that start with just enough mass to form the planets, suggested that the accretion of such a core would have taken 100 million years. The timescale can only be reduced to less than a million years if five to ten times the amount of solids necessary to form the cores was present. Thus, if this scenario is correct, then there should have been plenty of rocky/icy junk floating about the outer Solar System that would have to be disposed of—more than 50 Earth masses from Jupiter's region alone!

Again, there is circumstantial evidence for giant impacts in the outer Solar System that hint at a population of planetary scale missiles. The inclinations of the rotation axes of the giant planets, especially the bizarre 98° tilt of Uranus, cannot be explained as a result of planetary accumulation from a swarm of small particles. However, simulations that include the presence of a scattered swarm of Jupiter planetesimals with masses up to six Earths have reproduced successfully the range of giant planet axial inclinations. Uranus was probably turned on its side by a glancing impact from a body at least as massive as the Earth. Both Neptune and Saturn have inclinations of about 29° and so probably also experienced planetary collisions late in their formation process. However, for every such collision the chance of a near miss and consequent perturbation of the planetesimal's orbit would have been far greater. For Jupiter in particular, the probability of ejection per encounter is about 100-1,000 times greater than that of collision. Saturn would also have flung most debris crossing its orbit out of the Solar

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System, whereas Uranus and Neptune would have been more responsible for propelling icy planetesimals out to very distant orbits—one of the mechanisms proposed for forming comets.

Thus, current thinking in cosmogeny seems to support the notion of an excess of planetesimals of planetary mass that are disposed of by gravitational interactions as the era of planetary formation comes to a close. These would range in mass from "plomets" such as Pluto, right up to monsters of several Earth masses. Pluto and its moon Charon (probably itself formed by a giant impact) and the Neptunian satellite Triton may be good examples of what the smaller early-type UBPs might be like. Bodies composed of roughly equal fractions of rock and ice, they may be representative of Uranus and Neptune planetesimals. Triton avoided exile in the Oort cloud, or loss from the Solar System altogether by a fortuitous capture by Neptune, leaving it in a very peculiar inclined and retrograde orbit. The orbit of Pluto is presently stable, keeping it well away from Neptune, but this may not always be so. A future close encounter between the two may one-day launch Pluto into interstellar space.

How abundant might this variety of unbound planet be? In my paper I placed the number density of these objects in the solar neigborhood as being between 0.1 and 10 per cubic parsec, on the assumption that all single stars form planets. The lower estimate is probably too conservative, so the nearest interstellar planet to the Earth may be less than a light-year from Earth, skimming the outskirts of the Solar System. During a trip to Alpha Centauri, the nearest star system to our own, one would pass by roughly four interstellar planets en route.

DETECTION

So far, I have only been able to offer you speculation, based on imperfect theory, to back up my hypothesis of the existence of interstellar planets. What about real evidence? How might it be possible to detect an ISP? Since interstellar planets exist in an environment of darkness and cold, conventional astronomical methods would be hard put to spot them. They would produce no visible light of their own and since they reflect only starlight, optical methods of detection, used to discover Pluto, would be useless. Nearby giant interstellar planets with jovian-like internal heat sources might be detectable in the infrared. However, the IR surveys of the sky that have been done so far have identified nothing that might be a candidate interstellar planet. ISPs might also be detectable through their gravitational effects perturbing the path of a spacecraft. However, this is not practical yet as none of our deep space probes have left the Solar System. They are presently being monitored in an attempt to obtain evidence for the existence of a hypothetical tenth solar planet.

It is gravity which holds the key for the one possible detection of an interstellar planet to date, an event all the more extraordinary because this object, if real, *lies within another galaxy*. To describe this discovery, I shall first have to briefly tell the curious tale of the quadruple quasar system Q2237+0305,

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A.K.A. *Huchra's lens*.

Gravity can bend the trajectory of a light beam as can the glass lens of a telescope. Thus, we now appreciate that massive objects in the Universe can behave like gravitational lenses distorting the light from more remote sources, creating weird optical illusions. The quasar Q2237 + 0305 is actually a single object being lensed by the gravity of a foreground galaxy into four lobes. This large scale effect is called "macrolensing." However, observations of Huchra's Lens in 1988 by Cambridge University astronomer M. J. Irwin and colleagues showed a distinct amplification in brightness in just one of the lobes. This could not have been caused by motion or some other large-scale change within the lensing galaxy, otherwise all lobes would have been affected. Instead the effect has been interpreted as the first-ever recording of gravitational "microlensing," caused by a chance alignment of a single compact object within that galaxy with our line of sight. Microlenses are easiest to discover if the lensing body is of substellar mass because the amplification of the background source is more abrupt and easier to spot. Indeed, Irwin and colleagues calculated an upper limit of the mass of the microlens to be a mere 0.1 M_o—making it a lightweight red dwarf star. However their lower mass limit was calculated to be *just one Jupiter*. If this is right, then we have our first evidence of an interstellar planet—*800 million light-years away!*

For the time being, gravitational microlensing seems to be the only feasible method of detecting interstellar planets. We might search for them closer to home by instituting a careful long-term observation program of the slow moving stars in the galactic bulge. We would be looking for telltale brightness fluctuations caused by the chance, transient alignment of an interstellar planet in the foreground. Small unbound planets would not be detectable this way, but giants and massive singular planets just might be.

A SUMMARY

I have discussed above five different ways that interstellar planets might be formed, the validity of each particular formation mechanism, and likely number densities. A summary is now most definitely in order:

(1) *Singular Planets*

(*a*) Formation of isolated sub-brown dwarf mass bodies in star formation regions where stellar mass spectrum extends below 0.01 M_o. *Validity*: poor; *number density* ~ 10 per cubic parsec; *typical mass*:1-10 Jupiters.

(*b*) Formation of plomets of up to lunar size in molecular clouds. *Validity*: very poor; *number density* < 10^6 per cubic parsec; *typical mass*: Pluto.

(2) *Unbound Planets*

Late Type

(*a*) Ejection from a star system after supernova of the central star. *Validity*: good; *number density* ~ 0.001 per cubic parsec; *typical mass*: entire range.

(*b*) Gravitational scattering and ejection from a planetary system following a close encounter with a foreign star. *Validity*: good; *number density* ~ 0.0001

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per cubic parsec; *typical mass*: entire range but especially Plutos and Neptunes.

Early Type

Gravitational scattering and ejection of massive planetesimals during the terminal phase of planetary accumulation. *Validity*: fair; *number density* ~ 10 per cubic parsec; *typical mass*: Pluto-Earth.

It is clear that with a choice of possible origins of interstellar planets, these objects almost inevitably exist, probably in great numbers. The nearest one may be closer to the Sun than the nearest star. ISPs would be members of a very heterogeneous group comprising a wide variety of masses and compositions. Most of them would be early-type UBPs, new-born protoplanets cast into the interstellar deep freeze, their primitive atmospheres forming a frozen layer as hard as rock on the surface. Others might be featureless globes of black glass, devoid of any volatiles, their surfaces seas of frozen lava melted eons ago in the furnace of a supernova. An extremely exotic possibility is the interstellar planet that is sheathed in a layer of frozen nitrogen and oxygen, beneath which, embedded in any icy tomb, are found the cities of a civilization. A civilization extinguished by a rogue star that tore this world from its ecosphere condemning it to wander the depths of space for ever.

If an interstellar planet is ever discovered, who is likely to want to visit? That's not an easy question! They won't be useful stopping off points for interstellar travel, since after accelerating a spacecraft up to a certain velocity, they just keep going. When our descendants come to travel between the stars, the conventional scenario contends that the aim will be to leave one stellar ecosphere, arriving within another, whilst spending as little time over the interstellar journey as possible. Interrupting the trip to check out a dead world with a temperature close to absolute zero will be grossly expensive in both time and fuel. Exploring and settling an interstellar planet would be driven by other motives than mere curiosity. Perhaps future hermits or fugitives might appreciate the isolation and near invisibility of an interstellar planet. A culture used to living far from the Sun, such as Richard Terra's comet dwellers (*Analog* June 1991) might also find these dark and lonely bodies to be attractive. Tired of drifting through the void on the insides of metal cylinders or buried within balls of ice, some of them may set down on the strangest shores of all and settle the planets between the stars.

But that's a story for the pages of science fiction. . . . ■

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●There is nothing so innocent that mankind cannot introduce crime there.

Molière

●Everyone in the world dreams what he is, although none realizes it.

Pedro Calderón de la Barca

●Nothing is more difficult than separating things that are evident from those that are doubtful.

Lucretius

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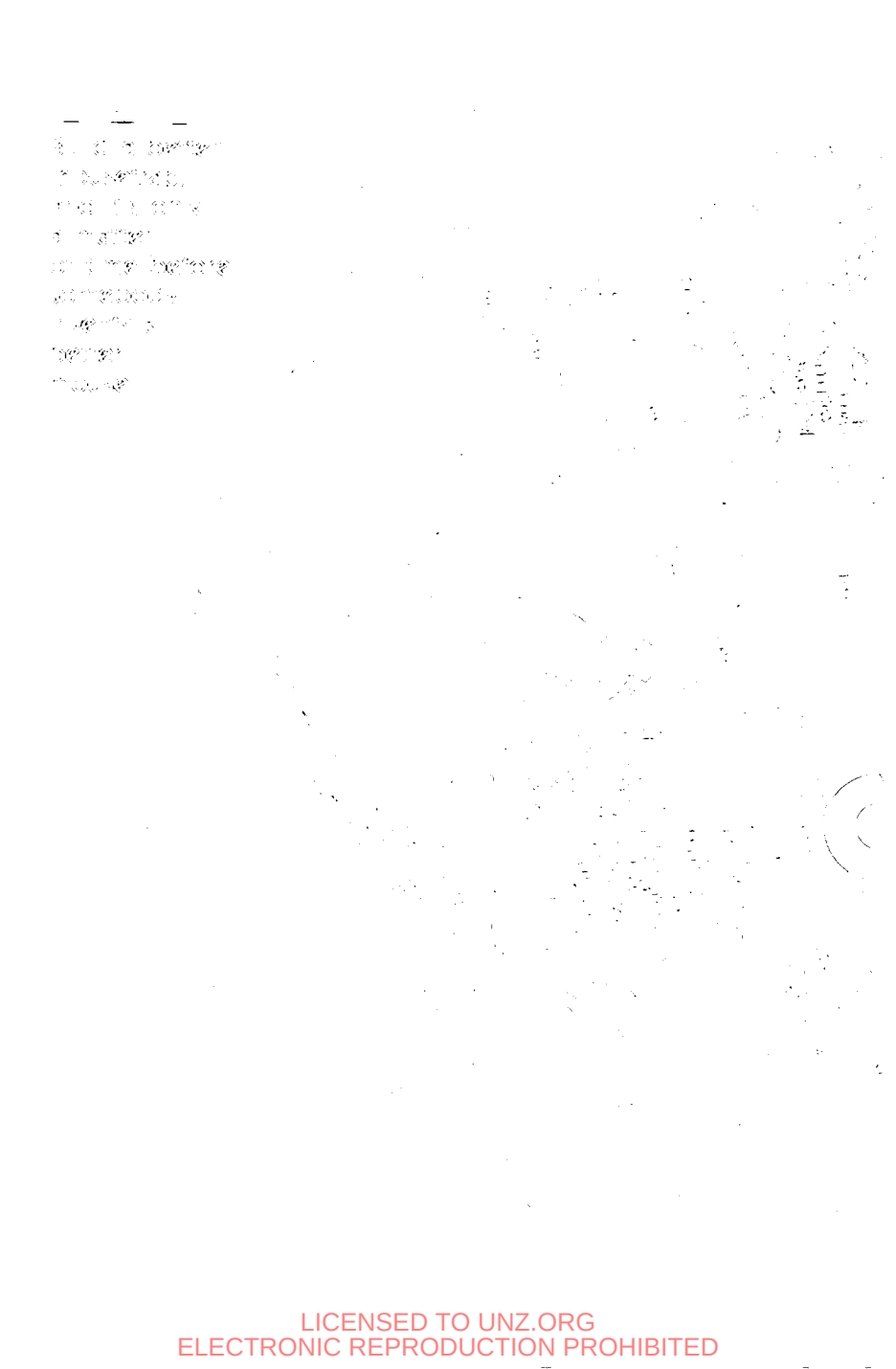

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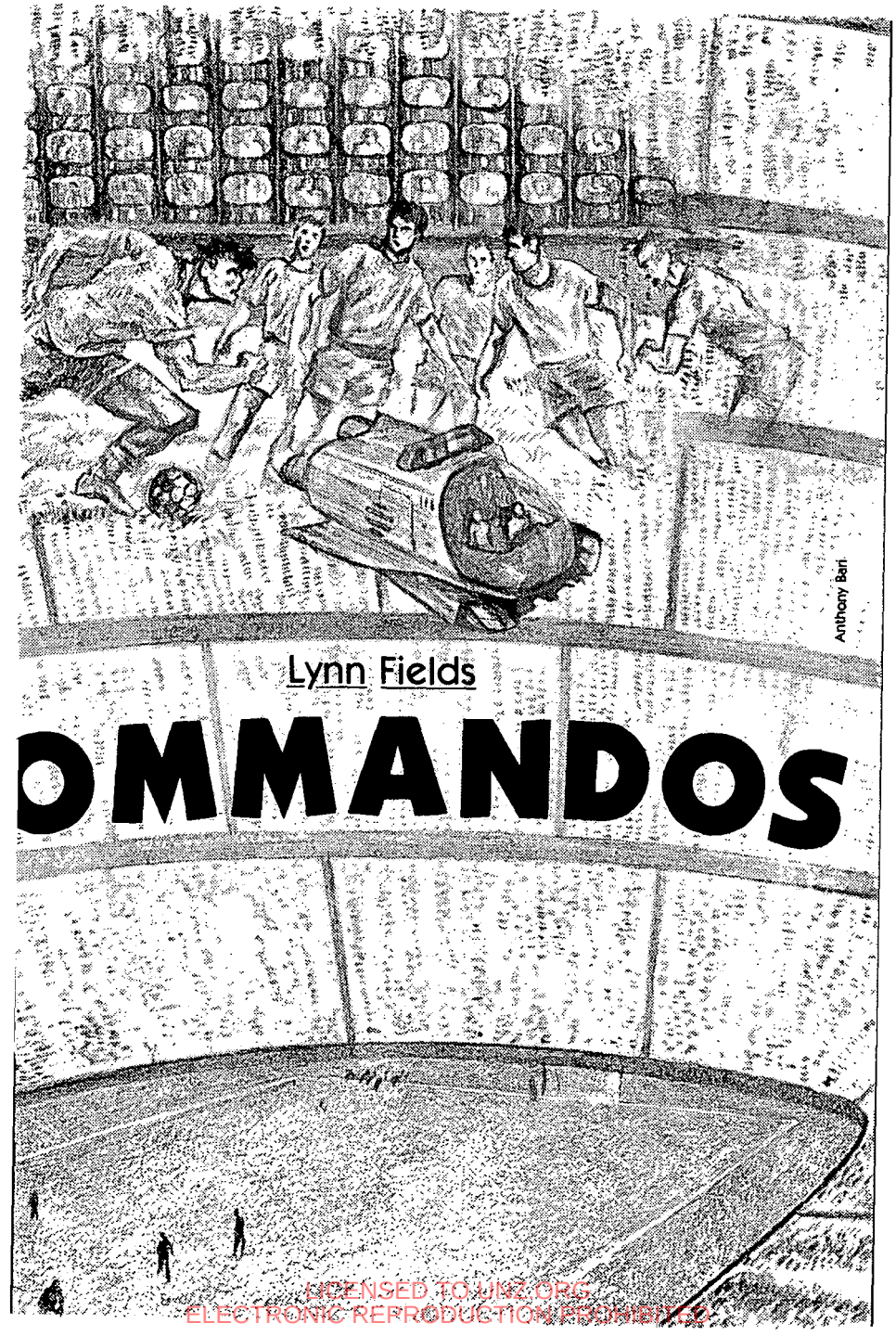

Lynn Fields

OMMANDOS

Anthony Bari

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Miguel Mendoza (Captain, Interpol) sat alone in his booth in ring 90 of Estádio Grosso. He watched the World Cup Soccer game, Argentina versus Great Britain, battling to a taut conclusion with half his attention. The rest was on his job, preventing violence at the game.

Not that that should give him much trouble. Estádio Grosso was the world's largest stadium and only two years old. A bowl 500 meters across, in which a fifty-story building could stand, dug out of the Mato Grosso Plateau. His seat was one of 259,257 individual teleport booths embedded in the surface of that bowl. Each had a large window that wrapped partway across the top of the booth. But since the windows were shatterproof—and the booths had no doors—he felt that the threat of trouble was slim.

"Uh-oh!" Lieutenant Ramón's voice said through his earpiece.

Mendoza touched his wrist comp cum watch to activate it. "What's up? Never mind, I see him." A customer below and to his left had managed to break from his booth onto the stadium surface. "*Floater,* we have a troublemaker on the stadium. Ring 75, southwest. He's carrying a long pole."

"Yes, sir. We'll get him."

He looked up at the nearly weightless SpyderCloth dome that floated on the positive pressure generated by the stadium's very necessary cooling system. Centered beneath the dome a hologram repeated the play on the field at 10X magnification. The police floater dropped from its hovering place above the hologram and swooped on the troublemaker.

The man had unfurled two flags, Argentine and British, from his pole and was waving them over his head. As the floater pulled from its drop and settled near the stadium surface, he touched a lighter to the flags and they burst into flame. They must have been soaked with something flammable.

Two officers hopped from the floater; one carried a fire extinguisher. The flag burner whirled his pole at them, warding them off with the fire.

Mendoza ordered, "Don't take chances. Just be quick."

"Yes, sir." The lead policeman drew his stunner and fired. The troublemaker collapsed and the other officer snuffed out the burning flags with an extinguisher blast.

As they loaded their unconscious burden into the floater, Mendoza yawned, stretched, and looked at his watch. It was a habit; the dataglasses he wore could display the time just as easily. On the field a referee called a penalty on the British team. "How many vandalized booths?" he asked into his comp.

"The flag burner makes three," answered Jorge Silva, manager of Estádio Grosso. "A very well-behaved crowd. Your Lieutenant Ramón hasn't had much to do. And the floater crew worked with admirable dispatch."

"Thanks, I'll be sure and tell them." Mendoza yawned again. He lived in Granada, Spain, Time Zone 12, so he had slept late that morning in order to set his internal clock to the Mato Grosso's Time Zone 8. It worked as poorly as usual.

And he had been in this booth for almost three hours. "Ramón, I'll be out of the booth for a few minutes."

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"Yes, sir."

He checked his shirt pocket, the seat ticket was still there, and picked up his stun rifle. Instead of the usual keypad, stadium booths had only two buttons: red for Send Me Home and Yellow for Toilets. He pressed the yellow button.

Picture society as a liquid.

Put a drop of ink into cold, still water. Since the water molecules are unenergetic, the ink diffuses slowly. If the water is hot, the ink diffuses more quickly. If the water boils, its agitation disperses the ink almost immediately.

Picture people as the molecules of society.

When Nakura Saji invented the teleport he turned up the heat on a simmering world. In seven years his long distance teleport pads linked the world—it eliminated the airline industry—turned the fire higher. People moved from place to place at whim. Impulse to action and no time for second thoughts. Society boiled.

The Vault War knocked the United Nations out of the debate club and into power; it became The Government. Peacekeeper armies squashed the war. Europe, the Americas, and Asia smoldered. Most of Africa had other problems.

The UN needed a police force to manage the lesser problems. Interpol was it. Therefore: Interpol at the World Cup in Brazil.

And, for the moment, life was much more peaceful.

The Monday morning before the World Cup game, at 8:35 A.M. in time zone 12, Miguel and Margarita Mendoza left home for work. It was raining in southern Spain, so they dashed the two blocks to the neighborhood teleport station. There they both squeezed into a single booth. Miguel fed an aluminum toll into the slot and keyed their destination. Three seconds later—*pulse*—

—They appeared in one of the ganged booths in Granada's Estación Central. Margarita kissed his cheek, said "Lamb for supper, then Carlota's dancing class," and ran for her connection.

Miguel walked past the long-distance (five toll) booths to Track 11, fed a single toll into the C turnstile, and joined several dozen commuters on the big teleport pad. Many had dataglasses perched on their noses, probably reading the morning news, but Miguel liked to watch his surroundings. He looked down the track in time to see pad E—pad D was empty—teleport out. At pad F a lift crew was unloading what looked like crates of fresh vegetables.

The warning light flashed. Mendoza checked the clock, 8:45 A.M.:12, and —*pulse*—

—He was in Madrid Internacional—the old airport. He looked out the windows as he hurried to gate 14. Fresh smoke marks marred a mothballed passenger jet parked on an abandoned landing strip. He wondered how long ago the fire had happened; and whether he had ever flown in that particular aircraft.

Miguel Mendoza had been with Interpol two years when Nakura Saji invented the teleport booth and eliminated aircraft from everyday travel. Nineteen years after that invention, Captain Mendoza paid his third aluminum toll of the morning, and—*pulse*—

—He ran up the escalator from UN

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Station in the Azores. Morning on Unity Island was clear and cool. He looked at his watch, 6:54 A.M.:10, and jogged across Unification Plaza to Interpol Headquarters.

Commandant Liz Brecht met him at the coffee pot. "Good morning, Captain. Bad news; Gaines has appendicitis. *You* now have World Cup security. Game is this weekend."

"But what about Lieutenant Ramón?" Mendoza protested. "He has seconded Gaines on the whole set-up. Let him do it."

"Too young," said the commandant. "And I don't really have time to argue with you. Now, get busy. You know what soccer fans can be like." She tilted her head to listen to something Mendoza could not hear. "Wash has a complete analysis on Estádio Grosso—it's in your space. Gotta run."

She turned away, then checked herself and added; "I'm waiting for your report on the Babatsky kidnapping."

"Solmans is collating it this morning. The nanny passed the Babatsky boy's teleport schedule to the kidnappers. After that, they had no trouble writing a commando program that got into the Net and, at the right moment, rerouted his home booth address."

He laughed suddenly. "Did you hear how we traced them?"

"No," said the commandant; she allowed herself an anticipatory smile.

Mendoza grinned through his answer, "Network security routines snapped a copy of the commando before it could delete itself and it included a programmer's copyright notice. All we had to do was find the man that matched the copyright." He shook his head in amazement. "Stupid."

"That's how we catch them," she replied as she strode away.

"I am on the job," Mendoza said to her back. He tapped his wrist comp. "*Intercom, Firth.*"

"Yes?" answered a voice through his earpiece.

"Miguel here. Join me in my office." He slipped his dataglasses from his pocket as he walked and began reading about Estádio Grosso.

Teleporticles—teleport superparticles—are passed in a direct booth-to-booth exchange. (For details, read Nakura Saji's *Sub-Second Transfers of Arbitrarily Large Data Stores* or Newton Park's popularization, *Teleport and Our Future*.).

Teleport *cannot* pass through the communication links of the WorldNet. The idea is absurd. Just think about breaking a human down into a digital pattern. (Be sure and destroy the original or you'll have duplicates. [Forget moral issues, they come up either way.]) Transmit those data bits as fast as possible and it still takes hours. And what about transmission errors and equipment failures? (Oops! You destroyed the original.) Ludicrous.

But the WorldNet *is* involved in each teleport: 60,000,000 teleport booths (including the long-distance commuter pads) can potentially address one another. The addressing and queuing problems are not impossible—late twentieth-century United States had twice that many telephones—but they are considerable.

The source booth addresses the target booth via the WorldNet. The two tele-

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port controllers then try to locate each other in three-dimensional space, allowing for factors such as the Earth's tidal bulge. If teleport tokens can be swapped, then the contents of the booth are teleported.

But that initial, electronic tap-on-the-shoulder travels through the WorldNet, where an infiltrating commando program can attempt to reroute. The felonious equivalent to forcing someone to dial a wrong number.

Mendoza reclined in his office chair facing the wall, reading against the featureless surface it offered, when Washington Firth walked in.

"Made it again, I see," Firth said as he dropped into the guest chair. "News this morning: a Johannesburg to Melbourne port sent a load of commuters to bit heaven last night." He had not ported in four years and he *always* mentioned teleport accidents.

"A simultaneous hardware failure at both ends," Mendoza answered absently. He had already heard others talking about the tragedy. "Safer than your bathtub—or that bicycle you ride to work. It has been more than a year since the last commuter failure."

It takes a spectacular intervention, or the unlikely double failure of equipment, to cause a true teleport disappearance. Not even a power failure will do it; the standing-wave receiver trap lasts for several seconds. Although the records were necessarily incomplete, the electromagnetic pulses from the tactical nuclear bombs used during the Vault War caused some teleport disappearances.

"When you say something like that, I am reminded of a story I heard in my youth," Firth retorted. "This company was photographing the internals of their new computer. But with every photograph the computer reset itself. They checked the power supply, looked for radio interference, everything. It turned out—" he paused dramatically.

Mendoza cut him off with, "A new circuit was sensitive to the flash of light from the camera. You've told me the story before." He stuck his dataglasses back in a pocket and tapped his desk control. The Estádio Grosso data projected onto the wall. "What about Estádio Grosso?"

"Aside from depending on teleport, it's the safest sports stadium in the world," Firth answered. "It has operated for two years without a stadium riot. I don't see how they could have one."

"Agreed. But they've never had a World Cup there."

"Five of the playoff games have been played there during the last two weeks," Firth corrected.

Mendoza scowled. "What about the stadium?"

Firth brought the stadium schematic up on the wall. "Look at this, a bowl dug out of the Mato Grosso plateau. A quarter of a million seats, each one an enclosed teleport booth. The only normal exit from a booth is teleport and they all have shatterproof, mirrored windows." He looked like a man trying to convince himself.

Mendoza shrugged. "I *never* go to stadiums. Until now. The year I was born my father was at the European Champions' Cup; thirty-nine killed and hundreds injured. And don't forget the

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last World Cup when Argentina and England played."

Firth shuddered. "I was a junior UN officer on that one. Eighty-six dead and seven hundred hospitalized. O'Neal and Samor disappeared during port—a bomb in the booth they used." He smoothed the back of his neck against a sudden chill. "Remind me to show you my scar."

Mendoza looked back at the projection and said, "Since it's the Argentines and Brits again, we can expect trouble." He drained his coffee in a gulp. "I want to get out to the stadium this morning and look it over. Bring me up to date."

Firth switched to his business manner. "We've correlated ticket sales to sales of suspicious products. We found a Polluxite shipment to Bristol that doesn't match British import declarations. Captain Gaines sent Lieutenant Ramón to check into it."

"Good," Mendoza said. "What else?"

"Sally traced a threat on the World Cup Committee back to a sorehead in Italy. A retired teleport technician named Benito DeMarco. He is under house arrest until after the game."

"Angry over the Italians' elimination?" Mendoza vaguely remembered hearing arguments about a referee's call during the play-offs.

"Yup," Firth said. "Now she's running down a ticket scam in New York. If that's all it is, of course, we'll turn it over to the local police."

Mendoza's first visit to Estádio Grosso impressed him despite his reservations about stadiums. The reality had an impact that diagrams did not convey. Beneath the milky gauze of the Spyder-Cloth dome, the stadium was a horizon full of tiers set with mirrored windows, each rim 250 meters away.

Jorge Silva, manager of Estádio Grosso, stooped next to a booth that was missing its window. "Here is one vandalized in the last game," he said. "We'll replace the window today."

Mendoza asked, "How do you catch vandals?" They spoke Brazilian Portuguese; he always used the national language when he knew it.

"When somebody breaks a booth's integrity, we reroute its teleport coordinates to our security cage." Silva shrugged tightly; he moved with a military reserve that went with his former career in the Brazilian militia. "We take them out and file charges."

Mendoza's comp beeped. "Yes?" he said in Basic.

Sergeant Camille's voice whispered through Mendoza's earpiece. "We're ready atop projector tower number five."

Mendoza looked at the southwest tower, rising to just beneath the canopy. A cluster of figures stood amidst the equipment. One waved in a broad motion. "I see you. Sergeant Kenan, are you ready?"

A lone figure standing in the middle of the playing field jerked to attention. "Yes, sir."

Mendoza looked to Silva. "May we test the hologram projectors now?"

"Certainly," Silva answered. He touched the button on his lapel. "Carera, activate the projectors."

The cluster of laser projectors atop each tower winked on, easily visible

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even in the diffused, morning light. An area above the center of the playing field fuzzed, brightened, and turned into a twelve-meter-tall Sergeant Kenan. The projected figure of Kenan turned slowly, pointing a measuring device at each tower.

"What's the magnification?" Mendoza asked, switching back to Portuguese.

"Variable, of course. That looks like about seven times." Silva nodded toward the projected image. "And see the quality, even in the daylight. Fans can watch the game on the field and still see closeups and replays just as if they were watching the vid."

"Hardly seems worth the bother to come. Especially for anyone seated in the outer rings." He lifted his comp. "Kenan, what do you read?"

Kenan, mimicked by his floating image, looked up from his instrument. "Definitely capable of threat."

"Agreed," Camille said. "I could unship these lasers in less than a minute and point them anywhere. Riot teams on all towers, I would say."

"I think so," Mendoza said. "Arrange for that with the Commandant. Armor and a floater."

Silva said, "If you wish. But we already post guards on the towers, and we have never had a problem here at Grosso. Further, if we must, we can evacuate the crowd to safety with a single command."

"And how long does evacuation take?" Mendoza asked. He tried to recall the figure he had read earlier.

"About twelve minutes. For economy's sake there is only one teleport unit for each 250 booths." Silva gestured at the surface of the bowl, painted in large pastel hexagons. "These painted areas mark the booths serviced by each unit."

Teleport booths still required economy. Not because of the one toll cost for each transmission, but because of the cost of the equipment. Within three years of their introduction, nano-machining reduced the price of a booth to the point that cities could scatter them around like metro stations. If you were moderately wealthy, you could even buy a private booth. Still, the eleven hundred teleport units of Estádio Grosso would have supplied a good-sized town.

Mendoza asked, "Why so long? Teleport only takes a fraction of a second."

The stadium manager shook his head. "Of course, but add to it the moments of network connect time and a delay while the teleport unit switches between booths. Twelve minutes."

"Well," Mendoza said thoughtfully. "I think we'll just put those teams there anyway. Senhor, if a gun fight develops, do you expect your guards to face death? And if they do face it, how effective will they be? Although I appreciate your experience you are hardly a terrorism expert."

Silva stiffened perceptibly. "You have the *authority* to do as you will, Captain."

Mendoza raised an eyebrow at Silva. "Senhor, I don't doubt your dedication. But we'll *all* answer to much more than stadium management if we allow a disaster." He shrugged one corner of his mouth. "Next, I need about two dozen seats. I'm going to put men out of sight in the stadium. Just in case."

"Just in case," Silva echoed, his sur-

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prise cracking through his stiffness. "But the seats have all been sold—for more than a month."

"Don't worry about that. Lieutenant Ramón will let you know which seats we have made available."

Mendoza's World Cup ticket took him to Toilet Facility Thirteen. The thirty-five toilet facilities scattered about Estádio Grosso were the only place that rival fans could get at each other. Thus, 140 police in riot gear guarded the toilets.

Mendoza was wiping his hands on his pants as he came back into the foyer from the men's room. He retrieved his stun rifle from one of the policemen. "Any problems down here?"

"Just once, sir," the policeman answered. "A couple of guys started pushing each other, but we sent them back to their seats. Not even much traffic right now. I guess the game is too exciting." Sound was not piped into the toilet area. It encouraged patrons to hurry back to their booths.

"It's a close game," Mendoza said. "Argentina 3, England 2." A panel above the row of teleport booths read: Max:200, Current:27, Waiting:0. As he glanced in that direction a woman with a baby blinked into a booth. Current:28.

"Yes, sir. Lieutenant Ramón has kept us advised."

"Oh." Mendoza fished his ticket from his shirt pocket and entered the nearest booth. The teleport booths in the toilet foyer had no buttons at all. He slid the ticket into its slot, withdrew it, and—*pulse*.

He was in his booth in ring 90. He wondered if the original holder of his ticket was watching the game from jail.

By the Thursday before the game, Lieutenant Ramón had traced the Polluxite shipment to an abandoned warehouse in the dock area south of the Avon River. Unlike the gentrified docks north of the river, this was a decaying slough of warehouses and sunken hulls. The few ships that could afford to sail the seas kept away from this place. The Bristol Skulls were only one reason.

But Mendoza and his team were in Bristol. He swallowed the last bite of his sandwich—it cost four tolls fifty at a dingy pub—and wiped his fingers on his filthy cloak. "Do you have my position?" he muttered into his comp. He checked the beard to make sure it still adhered.

Ramón's voice answered, "Yes. Ready when you are."

"*General*. Remember—move in quick and quiet. I'm leaving my transmitter on, so listen for your cue." A chorus of voices answered.

He and Sergeant Kenan shuffled slowly along the street. Their long, ragged hair and beards, ragged clothes, and ragged cloaks flapped in the breeze. They were just two more human wrecks in a wrecked district. As they wandered into the target block, Mendoza whispered, "Ready?"

"A team, check."

"B team, check."

He glanced up as the old truck that contained B team turned the corner and passed them; a rusted box with threadbare tires, spewing half-burned alcohol fumes. The driver winked at them. Mendoza's nose twitched at both the smell and the wink. He twisted the clasp

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of his cloak to activate his camera and said, "Cameras on."

Firth's voice relayed in from Headquarters: "Reading all cameras. It is now 2:13 P.M.:12."

Mendoza approached the front door of 152—heavy and relatively new—and whispered, "Now." He coughed loudly and rattled the handle. The door whipped aside and a hulking young man, his shirt slashed to display the patterned scars of the Bristol Skulls, filled the opening. He planted a big hand in Mendoza's face and pushed, saying, "Port out of here, skooge and skoogette."

Mendoza saw the Team A floater arc overhead for an instant as he staggered back. Kenan fired his stunner. The hulk collapsed, arms and legs twitching from the stun burst.

"Freeze!" Mendoza shouted as he whipped out his pistol. "Police!" The other three Skulls in the warehouse office were surprised, but not enough to freeze. He and Kenan fanned the room with stun bursts, bringing them down before they could draw weapons.

A crash and the roar of a truck engine, combined with a barrage of stunner bursts, echoed from the rear of the warehouse. They dashed past their victims into the warehouse proper. B Team already had it in control.

Mendoza reviewed his memory; he had heard glass shatter as Team A's floater came through the upper floor skylights. And he definitely still heard stunner fire. "Cover the stairs!" As a unit B Team opened fire on the stairwell, a laser bolt smoked the ceiling and a Skull tumbled, unconscious, down the steps.

The shooting stopped upstairs. Mendoza picked up the laser and handed it to the B commander. "How many, Ramón?" Loud Interpol voices echoed down the stairs.

"Seven," Lieutenant Ramón said. "Nobody down here got past us. The local cops may have 'missed' outrunners."

"Right," Mendoza agreed. He spoke too loudly, everyone did; men into the downside of an adrenaline rush. "*Camille*?"

Lieutenant Camille's voice reverberated through his earpiece. "Team A has secured the upstairs, sir. Come see."

As the police commandos carted out the stunned bodies, he surveyed the upstairs operation. On one bench, covered with broken skylight glass, were several toy darts, unscrewed to reveal hollow interiors. A rack on the wall held two dozen assembled darts with spring-loaded triggers instead of points.

Ramón picked up a partially assembled dart. "Wash was right. Binary explosives. Puncture the membrane between the chemicals and—instant bomb." He laughed. "*Bombino*."

Sergeant Kenan looked bemused. "So they had bombs. But they couldn't deliver them. A teleport scan might miss the binaries, but it would detect a launcher."

Mendoza shook his head. "Don't think so, tech."

Camille held up the oddly shaped bundle of wire and composites he was carrying. "Snap together catapult."

"But—" Kenan began.

Mendoza interrupted; "All of the Skulls had tickets within easy catapult range of the playing field."

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"Oh." A pause. "But why?"

"Revenge if Argentina won," Mendoza suggested.

"Or to keep Argentina from winning," Ramon added.

Camille shrugged and silently dropped his bundle back into the corner.

Mendoza turned to Ramon. "Follow the wagon back to the police station and make sure the right charges get filed. DF-5 on the fellow with the laser." He shifted his gaze to Camille. "You handle the reassignment of their tickets to Interpol."

Supper the night before the game was, as always, family talk time for Miguel and Margarita Mendoza. The children could participate, but their special time came after the table had been cleared.

Margarita dumped a chicken leg on each child's plate without interrupting their argument over the merits of various vid heroes. "Miguel, when will you get back from World Cup duty?"

"The game starts at 4:00 P.M.:8. That's 8:00 P.M. here, and I'll probably be there at least four or five hours." He looked up from his plate and shrugged his regrets. The plumpness of maturity had only made his wife more beautiful. "That probably means getting home around two in the morning."

She nodded. "Then I'd like to leave the children with Mother, she'll stay here, and port over to Wien. Helga Svenson is having an engagement party for Lise and Pyotr."

"It's all right with me. Mother has tickets to 'Aida' in Milano sometime soon."

"Next weekend," Margarita confirmed. "She said the children will be no problem. I probably won't be back until about midnight, so I'll fix the guest room for her."

Miguel caught her nod of now-that-that-is-all-settled out of the corner of his eye and smiled. "How was your day?"

"Panicked," she answered. "Chase Manhattan's lost about twelve million tolls for three hours in a transfer to Banco Madrid. Our director almost had a stroke. A commando program penetrated Chase's security for nearly a minute. Of course, they will pay the interest penalty. No work for us—David, *chew* your food—our security was already resistant to that commando."

Margarita was a security programmer for Banco Madrid. Security programmers had been a commodity for decades, fighting computer viruses—programs designed to replicate themselves and damage the computer programs and data that they could access.

Some computer programmers, however, realized that a virus was just a malicious toy. But a commando that would do a job—reroute teleport connections, intercept electronic funds transfers, alter government records—was far more rewarding. And the WorldNet gave them unparalleled access. Commandos and security, challenge and answer, thrust and parry. It was a fact of life.

"How about your day?" she asked.

"Followed up on Bristol today," Miguel said. "We couldn't charge the Polluxite vendor, he showed us plausible documents for the sale. Forged, but plausible. And since he is based in Singapore he can back up his claim of reasonable ignorance of the documents."

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"So, he didn't know that he was supplying terrorists?" Margarita asked.

"Guilty as El Diablo. But counsel says there is no use charging him."

"Why is it no use charging him?" Carlota suddenly asked.

Miguel looked at his six-year-old daughter in surprise; he had not noticed when the children had ended their argument and begun listening.

"Because it's the *law*," said David, with the arrogance of an extra year's wisdom.

"That's no answer, David," Miguel reproved. He gestured to the final sunset glow that colored the peaks of Sierra Nevada beyond their picture window. "It's like the sunset, Carlota. You see the last light, but you cannot see the Sun. UN Law says that you must be able to 'see the Sun' before you can bring charges. That's why we raided their bomb factory, our stunners and cameras whining; to catch it while it was working. Otherwise, we could only charge lesser crimes."

Carlota scowled at her plate. "Cid Magnífico would make them confess in the Sun Chamber."

David rolled his eyes, but had enough extra wisdom to keep his mouth shut this time.

Miguel laughed gently, his eyes inviting Margarita to join him. "But Cid Magnífico can also fly and turn invisible. I don't think anyone at Interpol can do that, so we just work real hard."

The British World Cup team captured the ball and fired it down the field, trying for the tying point. The Argentine goalkeeper leaped for the block, catching the ball in his belly, and the game signal blared. He leaped to his feet and threw the ball into the air exuberantly as his teammates converged on him yelling and prancing in delight. The British players tried to retire graciously from the celebration.

Even though the booths were enclosed the noise of the crowd—cheers and jeers—rumbled through the stadium. Mendoza checked the time, estimating how much longer he was on duty, as the teams gathered onto the commuter pads at opposite sides of the playing field: The Argentine players gathered in the middle of their teleport pad, still cavorting and waving to the invisible crowd, as an Interpol security team joined them.

"That about finishes it," Ramón said. "Doesn't seem like enough cheering for a World Cup."

Mendoza said, "The crowd is probably depressed by being in these concrete coffins. I can't wait to—" the Argentine team ported out, "—get out of here myself." He looked up at the hologram, then jerked to his feet.

The stadium hologram had switched to the awards banquet in Portugal, where the World Cup Committee gathered around a teleport pad, the Cup in the arms of one portly member. The teleport pad was still empty. "Where are the Argentines?" he demanded. "They are not at the banquet."

"Don't know," Lieutenant Ramón answered, his voice tightening. "Hang on."

Mendoza looked at the other, empty, teleport pad. "Did the British team get home?"

Sergeant Kenan's voice crackled in his ear. "No. I just checked with British

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Rail. I'm calling Brazil Teleport to see if they have a trace on the port requests." The holographic image of the awards banquet was a scene of distress now. A cry of rage swelled from the stadium booths as the crowd realized that something bad had happened.

"Turn off the hologram," Mendoza ordered. Could that Italian sorehead, DeMarco, have messed with the system? "*Headquarters, Firth.* The Argentines and Brits have been snatched by a network commando. Find Camille's comp signal; he was with the Argentine team. There must be a commando in the sys—"

"Brasilia says that there was some sort of explosion on the linking long-distance pads," Kenan interrupted. "British Rail did not receive coordinates for the second leg."

"The search is running," Firth's voice whispered back. "Who was with the British?"

"Ardoin." The roar of the crowd was getting louder; Mendoza felt a rhythmic thumping, thousands of feet stamping in unison. A riot was going on—invisible, compartmentalized, but a riot.

"The crowd is out of control," Silva, the manager, said. "I'm starting the evacuation program."

"No, you fool," Mendoza cried; then he felt and heard the humming pulses as the teleporters began emptying the stadium. "Not—" *Pulse* "—while a commando is in the system. Ramón, stop the evacuation immediately." *Pulse.* "*General.* Everybody out of the booths." The locks were already turned off on the booths used by Interpol. He pushed open his window—*pulse*—and climbed out onto the surface of the stadium.

Ramón said, "The commando program is still avoiding the security routines and my overrides. This control room doesn't have any way to disconnect from the network." *Pulse.* "The transmissions are obviously being rerouted."

Mendoza thought quickly. "Sergeant Kenan, take Silva and go kill power to the stadium teleporters." He looked around; it looked like all of the policemen stationed in booths were now on the stadium surface.

"Yes, Sir!" *Pulse.*

Could the commando find enough receiving locations to reroute everyone? *Pulse.* Or could it be that someone—No, impossible.

Pulse—CRACK! He whirled around at the crash of sound, even as he heard several more distant explosions. Several rings above him the window of a booth was shattered—inward. Implosions? He ran up the tiers toward the shattered booth, bracing himself to look into its interior.

Firth's voice suddenly crackled, "I can't find any signal from either Camille or Ardoin on the net. And Officer Sharp is missing, too." *Pulse* and several implosions.

The shattered booth was empty, except for broken glass. "Just a minute, Wash," Mendoza said. "Those of you near an imploded booth. Anyone in them?" Officer Sharp had been in a booth. Two or three voices chorused negatively. It was as if the booth had suddenly contained a vacuum. How could that have happened?"

And Mendoza *knew.* "They aren't rerouted, they're being sent to no-

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where!'' If a booth teleported to *someplace*, but there was no booth to exchange teleporticles, it would be empty. *Pulse* and more implosions. A sudden vacuum.

''Impossible,'' Ramón said.

''Imploded booths?'' Firth echoed incredulously. ''From an instant vacuum.'' *Pulse*. ''That has to be it.''

Mendoza said, ''Ramón, unseal the booth windows. Now! Camille is *gone!* The teams are dead.'' A moment later a rattle of sound circled the stadium as magnets withdrew the bolts that locked each booth window. *Pulse*—CRACK—Crack—Crack; glass sprayed around him. As the fusillade echoed across Estádio Grosso, he tapped his comp into the stadium speaker system.

''Open your booths immediately!'' His voice boomed from the speakers. *Pulse*. ''There is a teleport commando in the system.'' Windows began to flop open all around the stadium. Mendoza struggled with himself for a second, then added; ''This commando *kills!* Save your life! Open the windows.''

Most windows flopped open and many patrons began climbing out of their booths onto the stadium surface. The sounds of panic filled the stadium. *Pulse*. But that just made it more dangerous; several someones were bound to fall from the narrow pathways into open booths. ''Do not leave your booths. You are *safe* once the window is *open*. With the window open you will not teleport.''

Kenan's voice, panting, said, ''We've cut power to the teleport units.'' No *pulse*.

A voice Mendoza did not recognize said, ''We've lost power to the holo lasers.'' Still no *pulse*.

''The booths are down,'' Ramón confirmed.

Mendoza echoed the news across the speakers: ''Power has been cut to the teleport units. You *are safe* in your booths.''

Mendoza sighed shakily; he felt his knees begin to quiver. ''Good work, all of you. No more teleports.'' Despite his last message, several thousand people had climbed to the surface of the stadium.

He announced again, ''The teleport system is turned off. There is no more danger. Please stay at your booths so that you do not get hurt.''

Mendoza looked around where he stood and felt the hair rise on the back of his neck. Nearly twenty booths in his teleport group had not opened their windows. There was no one in them and it could have been him. He calculated quickly: about 20,000 disappeared. No, 20,000 dead.

The sounds of panic began to ebb, though hundreds more had climbed onto the stadium surface. ''Firth, get a team on this commando *immediately*. Ramón, we'll need food and drinks if this lasts very long. We'll also—''

Firth's voice crackled in his ear, interrupting him. ''Miguel, I'm getting reports of teleport passengers disappearing in the Americas and Europe. —And Japan.''

Mendoza felt a roaring in his head. He shouted; ''Shut down the network. UN Priority!'' Margarita was in Wien. ''The commando is in *the Net*. Do it! Do it! Do it!''

* * *

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Their floater was nearing Brasilia before Mendoza finally got a call through to Wein. The network had rejected his first nine calls due to traffic. The result of his hour and a half of calling was unsatisfactory. Oleg Svenson's recorded voice assured all callers that he would see that his guests made it home safely. Margarita was not home in Granada. And now it seemed that she was not with the Svensons either. He hoped that Oleg knew what he was doing.

He closed the link from his comp and looked out the window. Below them a fire was raging at a shopping center. Several fire department floaters surrounded the blaze, spraying it with glittering streams of water. Beyond them, a police barricade kept the crowds away.

He pointed. "What's that?"

The floater pilot said, "A fire started while a food store was being looted. Traffic control warned me about it."

Mendoza rubbed the bristles on his cheek. "Looted?" he said slowly. He pointed at a police floater hovering high above the action. "Take us over to the command car. I want to find out what happened." He twisted around and tapped Ramón and Kenan on their knees. "Wake up."

As their floater nudged up beside the police floater, Mendoza lowered his window. "Interpol," he said, showing his badge. "Was this arson?"

The police captain shouted back, "No, looks like it was an accident. People are robbing food stores tonight, not burning them."

Mendoza had been concentrating on the tragedy of three hundred thousand humans teleported to infinity. It looked like he had overlooked the ripples. He asked, "How many arrested?" And how many ripples? He saw several emergency floaters scooting across the sky, too many in motion.

The captain gave him a pitying look. "One man who pulled a knife on somebody. Otherwise, we stand guard. What's to be gained in arresting panic-stricken citizens who will risk their lives to feed their families? We couldn't even begin to arrest them. We just try to keep anyone from getting hurt."

"Is it the same everywhere?" As he asked the question he spotted what looked like a hospital a few blocks away. It was a hive of activity: ambulances coming and going, and crowds in the streets.

The captain shrugged. "Probably. Some storekeepers opened their doors and passed out food until it was gone. They will be remembered. But people aren't stealing vid units tonight."

Kenan asked, "But, why? There is still plenty of food for tomorrow."

The captain answered, "Without the Net, no food will come to town tomorrow. By the end of the day the stores would be empty."

"But more can be brought in by floater," Kenan said.

Mendoza shook his head, remembering. "No, I remember how many trains and trucks used to carry food."

The police officer laughed—a short cough. "That's right. Most of us can't even flee the cities. No way to leave without teleport. Soon the crowds will figure that out—then a floater will be worth your life."

Mendoza nodded slowly, finally understanding. The problem was not Margarita in danger, nor was it three hun-

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dred thousand effectively dead —disappeared while teleporting. The world was hanging on the edge.

The captain added, "Just get the network going again before we start eyeing each other for the menu."

Half an hour later, in the rear seat of a Peacekeeper interceptor headed for Unity Island, Mendoza had all remaining information on Benito DeMarco released to the news agencies. And Interpol offered a ten million toll reward for him—if he was captured alive.

Mendoza turned and looked down from Firth's office window onto a crowd of protestors, about three hundred strong, gathered under the lights. They waved signs and mouthed angry words. He had seen crowds of half a million fill Unification Plaza with protests and celebrations. Without the Net, the other four hundred ninety-nine thousand could not get here.

In fact, even headquarters was half empty; Interpol officers were as cut off from travel as the general public. The lab outside the office was the only room that he had seen full. The whole lab area was in the disarray produced by frantic people working through the night. Technicians and several brands of teleport booths were enmeshed in a web of wires and test instruments.

Mendoza looked at the European map projected onto the wall and asked, "How sure are you that DeMarco was in Delfrecht?" A spray of short red lines centered on Torino were scattered across the map. Some bent to a second connection; some of those to a third. But one line staggered a twisting route in seventeen legs across the continent to the Netherlands.

Sally Nann pointed at the long red line. "Nobody travels long distances that way. Why pay seventeen tolls on local teleports when three or four tolls via the long distance links will take you almost anywhere? This is from last night's teleport log." Her frock, beneath a lab coat, was freckled with blood. A bandage on her cheek marked the source.

Mendoza nodded. "Smart, Sally. Of *course* DeMarco would know the safe routes."

She said, "I wish I'd known which were safe. Then I wouldn't have been standing by that booth when it imploded." She touched the bandage. "At that, the man ahead of me blocked most of the flying glass."

"Just be glad you weren't in the booth." Mendoza traced his finger across the projection. "So, he could have gone almost any place in the European mainland, hopping from booth to booth. But, is he still there?"

Firth said, "It was nearly two hours after the Net was closed to teleport before we thought of analyzing the logs for this trace."

"I was at the infirmary," Nann interjected.

Firth nodded and continued; "Within another half hour, Peacekeepers had sealed off Delfrecht to surface and air travel. We're pretty sure that that was DeMarco. But he had two hours to move on."

Mendoza asked, "Any runners near there?"

Nann keyed into the Border Patrol database. "There have been a half

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dozen runners on the Net during the last hour. There were more, but DeMarco got some of them."

As DeMarco had dramatically proved, the WorldNet was susceptible to tampering. Runners used commandos to travel the world without paying. Some trafficked in interdicted substances. They had to run; normal teleport operations would detect their cargo just as it would detect weapons. A runner does not want to teleport into a police station. The Interpol Border Patrol specialized in hunting them.

Nann flashed the runner tracks onto the map in green. None of them touched the Netherlands. "It doesn't look like he could have run from there," she said. "But he may be running an undetectable commando. I've heard rumors of such things. Or he could have a surface vehicle."

Mendoza nodded, then spoke into his comp. "*Commandant*. Mendoza, here. I need a raid force for Delfrecht, Netherlands. DeMarco may still be there."

"Done," Commandant Brecht's voice answered in his earpiece. "Now get out of here. Secretary-General Farquhar has summoned me to an emergency meeting of the Ruling Counsel. I need to say that you are about to make a capture."

"Yes, ma'am," Mendoza answered, signing off. "*Ramón,* we are going to join the Peacekeeper troops at Delfrecht. Arrange a task force. Thirty officers if there are that many available."

"Yes, sir," Lieutenant Ramón answered, and signed off.

Mendoza asked, "What about the commando?"

Nann looked up from the lozenge she was unwrapping. "Dexter got a watchdog routine onto the Net. We can now monitor it, but we don't know how it works. We can't find what is common about the booths that imploded. I think that has turned out to be the wrong track." She popped the lozenge into her mouth. "I'll check DeMarco's seventeen booths next."

Firth waved him away, an exhausted gesture. "We're still trying. For what it's worth, the code looks like it would have only affected Estádio Grosso if it had been written correctly. Go get your team together. We'll let you know."

Mendoza disconnected his link to Major Heukels, the commander of the Peacekeeper force in Delfrecht, and looked at the monitor in the corner of his office. The constant feature of the news broadcasts was DeMarco's picture, the ten million toll reward for his capture, and the disaster. He wondered how DeMarco planned to escape billions of people who wanted him dead.

Ramón strode into the office. "We got twenty-three volunteers. Kenan, you and I make twenty-six. The Peacekeepers are sending one of their shuttles to ferry us to Rotterdam. They'll have floaters to take us the rest of the way."

"Good. Major Heukels has agreed to wait for our arrival before taking action. He had already waited for sunrise, so a little longer won't matter."

"The Sun is up?" Ramón asked. "Time flies, et cetera. The shuttle will be here in an hour."

"Good. Take a nap if you can—" His comp signaled. "Excuse me. *Answer.*"

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The voice in his ear said, "Miguel." It was Margarita.

He felt his heart skip. He swallowed; clearing his throat. "Margarita. You're safe. I'm safe, too." He wanted to say loving things, but Ramón's presence hampered him.

"Miguel, I love you," she said. It said much more than the simple declaration.

"Me, too," he replied. "I'm about to go on a raid. Are you home?"

"Yes," she said. She spoke more briskly, as if she sensed the urgency of his situation. "The Svensons have a camping floater. Oleg figured out right away what to do; he and Helga piled all of us into their camper and flew us home. I just got in. The Iberian Peninsula was the last place we reached."

"Is he there?"

"No, they headed out to the mountains. Oleg said that a floater would be worth your life in a city. So they plan to camp out a few days and wait for the trouble to blow over."

Oleg had always been quick. "Anyway, you're safe. I have to go now."

"Miguel," she said, her voice tensing. "One thing you should know first. No one knows where your father is."

Mendoza strode into Firth's office. "What do you have?" he demanded. "We're about ready to leave for the airstrip."

Nann said, "The imploding booths were a red herring. It seems that a booth implodes if it is on the other end of a teleporticle exchange with a DeMarcoed booth."

"Yes," Firth said, stepping on her words. "An infected source booth sends its teleporticle to infinity. A clean target booth sends its teleporticle correctly. But since it receives nothing, it now holds a vacuum. Boom!"

"So when the booths at the stadium started imploding?" Mendoza asked.

"It meant that the commando had made it into the WorldNet," Nann answered. "Booths on both ends of the exchange were infected. Then they both go boom."

Firth continued, "We scoped out last night's teleport transaction logs. We finally figured out that all missing teleports *originated* from booths built in the last four years. The target booth does not seem to matter."

Mendoza felt his hand shake. He decided against another cup of coffee. "What happened four years ago?"

Nann answered, "The Mentor teleport module. But it is almost entirely safety improvements. Nanocrafted sapphire chips, improved receiver trap. *Non*programmable. It should be invulnerable to commandos. Or to viruses—which is what the DeMarco program really is."

"So, what now?" Mendoza prompted.

She looked up from the lozenge she was unwrapping. "So, we're working as fast as we can. DeMarco Vaccine 1 was ineffective; it never reduced penetration below 50 percent. Jansen and Koto are working on Vaccine 2."

Firth said, "But we don't really know how the DeMarco works. It does all sorts of things, like resets a booth's network controller. But if the teleport module has a target address, it doesn't need the network."

Mendoza chopped his hand, cutting

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off the explanations. "Enough. You'll get it. But this means that *you* can send me, us, to Delfrecht through safe booths." He looked at their faces. "*Ramón*, cancel the shuttle. We'll be porting."

"We *need* DeMarco alive," Mendoza told the policemen lined up beside five of the teleport booths in Dispatch Seven. He kept his emotions suppressed; DeMarco could be executed only after he had been drained of knowledge. "We will arrive through the five older booths in Delfrecht. Clear out of the booths immediately on arrival to make room for your partners to come on through."

He stepped back and put on his dataglasses. "Lieutenant Firth has programmed a path of about two dozen ports—through the local teleport exchanges. Anything to add, Lieutenant?"

Firth cleared his throat. He looked ill. "Stay in the booths until you get there; they will port automatically every five seconds. The WorldNet is about 90 percent cleared of DeMarco's commando now. The number in the left corner of your dataglasses shows the current penetration of the Net. If the number is circled, your area is contaminated."

He looked even sicker as he held up a card showing the universal negation symbol. "If this appears in your dataglasses, you are in a dangerous booth. Open the door immediately and *get out*."

Mendoza said, "If that happens, you are out of the raid. Report to the local police and wait." He stepped to the head of the line for Booth 1. "Remember, too, that we will be working with the Peacekeepers already in Delfrecht." He closed the door, his watch read 9:52 A.M.:10 and—*pulse*—

—he was in Portugal; a fishing village whose name he had already forgotten. Everything looked normal at 11:52 A.M.:12. Then—*pulse*—

—a street in Lisbon. The windows were smashed out of a store ten meters away. Black ribbons fluttered from three front doors. He looked—*pulse*—

—at a peaceful village. He was in the country, at a pair of hiker stations. Then—*pulse*—

—another village. A large crowd exited the cathedral to the slow toll of bells. So many wore black that he was—*pulse*—

—almost ready for the shock of a blanket-covered body on the street of the next town. Police and medics stood about with the unhurried air of being on hand too late to stop a suicide. Again—*pulse*—

—he ported into Madrid. He recognized the skyline. More black banners draped the neighborhood. A floater, riddled with buckshot, was smashed against the corner of a building. Someone had figured things out, but—*pulse*—

—port, and see, and port, and see, and port—

Whatever mercy he had for DeMarco was flushed from his soul long before he reached Delfrecht. An uncircled 4 percent in his dataglasses reported that Vaccine 2 was working well. All he wanted was the secret to DeMarco's commando before the murderer was executed.

He stepped out of the booth and looked around. A Peacekeeper Major

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and two soldiers stood guard by the booth. He was at the edge of Delfrecht's central plaza; the shabby plastcrete building on the east was probably Town Hall. The open-air market was stripped, the windows of a nearby grocery smashed and its shelves bare. Several doors that he could see were decked with black ribbons or wreaths.

Sergeant Kenan ported into the booth and stepped out.

The peacekeeper major said, "Major Heukels. Captain Mendoza, no one has left the village since we arrived at 3:30 this morning. All booths and the town perimeter are guarded."

"Thank you. Excuse me a moment." Mendoza spoke into his comp, "*Ramón*?" In his dataglasses he saw the street map of Delfrecht overlaid with symbols for floaters, teleport booths, and Interpol officers.

"We're in the air," Lieutenant Ramón's voice answered. A few seconds later four Peacekeeper floaters drifted over the town.

Mendoza turned back to Heukels. "Major, please make the announcement." There were now half a dozen Interpolice waiting beside the booth. Mendoza told them, "Scatter out."

A moment later the major's voice, speaking Dutch, boomed from the floaters. "Attention. Attention. Benito DeMarco, wanted for *questioning* in last night's disaster, may be hiding in Delfrecht. He is dangerous. Do not try to capture him; tell the nearest policeman or Peacekeeper if you have any information." He repeated the message in Basic.

Mendoza felt the crowd come alert. He heard doors slam. Men and women with watchful eyes exited onto the narrow streets. Others leaned out from upper-story windows. They wore the faces of hunters. One bandaged, old man on crutches hobbled over to the teleport booth across the plaza and positioned himself beside a Peacekeeper corporal, his back to the booth door.

"Fortunately, Delfrecht is small," Heukels said. "It never recovered from the Vault War. But, why would DeMarco come here?"

"Don't know," Mendoza answered. "His great-grandmother was Dutch. But we can't link her to this area. Start the door-to-door sweep, please."

He looked around slowly as the order was passed. Something tickled at his mind. Something?

He heard a dull thump and whirled around. The Peacekeeper corporal across the plaza slumped to the ground, a broken crutch across his shoulders. The old man was in the booth pulling a programmer's computer from beneath his baggy, brown sweater.

"DeMarco!" Mendoza shouted. And it *was* DeMarco. Disguised by dirt, costume, and bandage, but still Benito DeMarco and still in Delfrecht. The distance was too great for Mendoza's pistol, but the Peacekeepers whipped their stun rifles from their shoulders.

DeMarco looked up with a smile and disappeared.

"*Firth*," Mendoza shouted as he ran for the booth. "DeMarco just ported out. Get me a runner trace." The 3 percent in his dataglasses jumped back to 4 percent—and now it was circled. The commando was back in this part of the Net.

His mind clicked; he dug in his heels

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and whirled back to the booth he had arrived in. Firth had not sent anyone in through the booth DeMarco had just used. Therefore, it was deadly for him to use it. "Kenan! With me!" They crowded into the booth together.

Firth said, "Got him. Here goes; two ports." And—*pulse*—

—a rural booth. And—nothing.

"Firth?" Mendoza demanded.

"Hold it. The next booth is not receiving. Finding another." Then —*pulse*—

—another town.

"Northwest!" Firth said. "About five blocks."

"Right." Mendoza and Kenan burst from the booth and ran, following the arrow that appeared in their dataglasses. Five blocks later they found a small square with two booths. One had been overturned and burned. The door to the other was jammed open with a wadded brown sweater.

As Mendoza kicked the door open the negation symbol appeared in his glasses. He backed out. "*Firth?*"

"Captain, this way," Sergeant Kenan shouted. "Look at the crowd." He sprinted from the square.

Mendoza saw what he meant. Two blocks away a crowd was chasing someone. It had to be DeMarco. He panted, "*Firth*, check booths west of here," and sprinted after Kenan.

Firth said, "I have the local police intercepting. Ramón and Spence just ported in west of you."

A burst of stunner fire sounded from ahead. Mendoza accelerated his sprint. He felt a stitch flare in his side. The crowd had stopped running and milled noisily. He punched a hole through them in Kenan's wake. Part of the crowd gathered around a constable stretched, groaning, on the ground. His holster was empty.

Kenan stopped short. "Sir!"

The rest of the crowd was gathered around a teleport booth. Ramón and Spence sprawled unconscious beside it.

Mendoza snapped, "Stunned. Leave them. *Firth*, get us on his trail again." He dragged Kenan into the booth. "Ready!"

"Got it," Firth said. —*pulse*—

—They were in the suburbs of a larger city.

"Stay in the booth," Firth ordered. "I'm tracking him. OK, here—" *pulse*—

—The central plaza of another small town leaped up around them. Mendoza flung the door open and danced out onto the pavement, his left fist pressed into his aching side, his right clutching his stun pistol. "Firth?"

"He's near you."

"Look!" Kenan shouted, pointing his stunner over Mendoza's shoulder.

Mendoza dropped, spinning, to the ground, bringing his pistol to bear. DeMarco stood in a booth fifty feet away, grinning fiendishly as he tapped a command on his computer. Mendoza and Kenan fired; DeMarco disappeared.

"Almost had him." He realized that he was shouting, but he could not help it. They crowded back into the booth. "Get us after him."

Several seconds passed. "*Firth!*"

"Searching," Firth said. "Hold on." A long pause followed. "Miguel? I can't find him. The address he ported to shows no receipts. I don't find any other receipts in the local switching

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range."

The 3 percent in Mendoza's dataglasses was circled. "Keep hunting," he said as he pushed back out of the booth. "He couldn't have been stupid enough to send himself to infinity."

He ran to the booth DeMarco had used, Kenan on his heels. He stuck his head into the booth, but the negation symbol did not appear in his dataglasses. "It *is* an old booth."

"What do we do, sir?" Kenan asked.

Mendoza held up a hand as Firth said, "I think you should call off the hunt. I can't find any motion on the European Net. He must have disappeared." His voice was touched with hysteria. "How could that have happened? Our analysis said only booths built in the last four years."

Mendoza looked down at his pistol. He could feel pieces falling into place. "Wash, listen to me. Kenan and I fired just as he ported. If our stunner bursts hit the booth *just* as it transmitted, could that have lost him?"

"I suppose it could," Firth answered slowly. "If there was electromagnetic interference from the stun burst at exactly the right instant. Let me ask Sally."

Mendoza holstered his pistol. "Sergeant," he said, gesturing for Kenan to do likewise.

Firth's voice was back. "Yes, Miguel. There is a five to ten millisecond window after the controllers have synched teleport tokens and before the actual port when a stun burst might scramble the address register of the teleport module."

"Like your story of the camera flashes and the computer that reset itself."

"Yes, yes." He could picture Firth's hands flailing in excitement. "If the address was shifted by more than a few feet it would be outside the radius of the receiver trap. Off to forever. It's a small window, of course. I'll—"

Kenan asked, "So we killed DeMarco?" He looked at his hands, they shook.

Mendoza touched his shoulder. "Yes."

"—back to headquarters," Firth continued. "We still need to figure out how DeMarco's commando works."

Mendoza shook his head, then realized his mistake. "You *know*, Wash. Think about it. The commando cannot touch the teleport module, but you said it resets the Net controller. When a controller resets, does it produce a burst of static or a power surge? Anything that could interfere with the teleport module like our stunners did? At the right instant?"

The gibbous Moon low over Sierra Nevada glowed into the Mendoza's living room. They sat on the couch before their picture window, Miguel's right arm tightly around Margarita. Too tightly for comfort, though she did not complain. She asked, "Miguel? The network is safe again?"

"No, not safe," Miguel said. He stroked her arm slowly. "Network security routines are upgraded. But teams will be working for days to insert insulators between each network controller and teleport module. First the commuter pads, then working down to personal booths." He kissed her gently. "Interpol is certainly not the only one that

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captured the commando from the Net. If someone uses it again, we can still lose dozens of persons before security purges it."

She sighed softly and shook her head. Her hair tickled Miguel's nose. "So sad. Why is there always someone so willing to hurt the innocent?"

He leaned his face against the top of her head, breathing her warm scent, and let the moments pass silently. He had no answer for that question. After a while, he said, "Margarita, Wash tells me that a house just down their block is for sale. And there are plenty of jobs on the island." ■

IN TIMES TO COME

● From time to time science fiction writers have tried to write about the challenge of climbing a tremendous mountain on some other planet, but seldom, I fear, very successfully. Too often they have told us their mountain was far higher and more formidable than any on Earth, but it *felt* just like Everest, or maybe a little more so. In fact, such a mountain (assuming you can figure out how it could exist, which is itself no small challenge!) would be not just quantitatively, but *qualitatively* different from anything we've experienced. Our lead novella next month, by Rick Shelley and Lee Goodloe with a spectacular cover by Bob Eggleton, is one of the few that delivers on its promise; its mountain is at once believable, awesome, and utterly alien. It is, in short, the science fiction mountaineering story I've been wanting to read for a long time, and I think you'll enjoy it, too. Why did Shelley and Goodloe take on such a challenge? Perhaps the same reason that gave their mountain its name. Mt. B.I.T.—"Because it's there!"

July is, of course, one of our semiannual double issues; and it, too, is both big and impressive. The smorgasbord of fiction includes a wide range of stories by writers like Ben Bova, Dean McLaughlin, Maya Kaathryn Bohnhoff, Grey Rollins, and Kathy Tyers. And Geoffrey A. Landis, well known in the circles of both science fiction and fact, offers an item on "The Demon Under Hawaii"—which, though frankly speculative, belongs more to fact than to fiction.

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The Alternate View

WALL-TO-WALL DATA

G. Harry Stine

In 1886, Lord Kelvin (William Thompson) stated: *"I often say that when you can measure something and express it in numbers, you know something about it. But when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely, in your thoughts, progressed to the level of science, regardless of what the matter may be."*

Those areas of science, engineering, and technology that have taken Lord Kelvin's advice to heart were once referred to by Robert Heinlein as the "hard subjects." They require real knowledge, education, and training. On the other hand, Heinlein referred to many of the so-called social sciences as the "fuzzy subjects." These don't require knowledge, only scholarship.

Some practitioners of the "fuzzy subjects" have tried to put numbers on what they're doing in a valiant try at quantifying it. Some of them have yet to understand the difference between quantizing and measuring. They've discovered that the application of statistics lends an air of Kelvinian respectability to their work. I discovered this a long time ago when I tried to major in psychology. I took a lot of courses in statistics. In many ways, statistics is a middle-level way station between the bean counting of bookkeeping and the mathematical concept handling of algebra.

However, the information and techniques I learned in statistics were later very valuable to me when I had to design experiments, evaluate results, and establish quality control standards. Therefore, before you square off with word processors at fifty paces, allow me to point out that indeed I do know and respect the subject of statistics when applied to measurable factors. I say this lest a reader may garner the opinion that I am too hard-nosed in what I say hereafter in this column.

In fact, some of the practitioners of the hard subjects, such as those engaged in modern physics, particle physics, quantum mechanics, and other esoteric applications of the modern equivalent of white magic, have had to embrace statistics to get some handle on their wild results.

Statistics is a valid method of manipulating data so patterns can be seen. However, few people other than statisticians really understand statistics. This does not prevent people from being awed by statistical presentations and statements.

The recitation of statistical results doesn't impress me or get me to believe in the results unless I also know the margin of error, the sample size, and the question asked of the Universe or the polled individual. Such statements as "70% of the tropical rain forest has been destroyed by mankind," cause me to ask some questions in re-

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turn. "Where did you get your data? How was the information obtained? What measurements were made and with what equipment having what accuracy and repeatability?" And the usual ones about sample size, etc.

Some news media personalities have made the Grand Extrapolation from a statistical probability to a catastrophic finality. Just because one piece of the sky was seen to fall doesn't mean the whole affair is immediately coming down around our ears. The loss of one shingle from my roof in the wind gust from a thunderstorm doesn't mean that rainwater will pour into every room of my abode.

I used this as an example because the greens of the environmental movement are prone to make such statements. I have no doubt that they're seriously concerned. However, I'm also worried that they may be like psychologists who are trying to figure out what's wrong with themselves. (Sociologists, on the other hand, tend to be concerned over what's wrong with everyone else.) Dr. Dixie Lee Ray has more to say about stretching the data, misinterpreting the data, or drawing conclusions from a single datum point. I highly recommend her book, *Trashing Planet Earth*. (Regnery Gateway, 1991, ISBN 0-89526-544-3) She makes a good case of how science, measurement, and data presentation are being bent to serve personal agenda. You ought to read what she has to say about it rather than get it second-hand from me. Dr. Ray cites her sources as a good scientist should. Besides, it's a book you should read if you're concerned about the terrestrial environment.

On the other side of the house, the Kelvinians have proceeded to instrument and measure everything they possibly can.

To measure some physical parameter, a device called a sensor must detect change. This change must be expressed as a phenomenon that can be compared against a standard condition. It used to be that one searched hard for a sensor that would provide a linear output directly proportional to a linear change in the phenomenon being detected. Computers and digital processing have made it possible to linearize almost any sensor output. Thus, sensor systems capable of measuring physical parameters by both intrusive and remote methods are available. Not very long ago, they were just a dream.

For example, 30 years ago I was involved in industrial research on measuring the water content of paper as it is produced on Fourdrinier papermaking machines. Since web speeds ran as high as several hundred feet per minute for newsprint machines, frequency response and sampling rate were important. Furthermore, one dared not tamper with the process because it's so complex. We looked at NMR, IR, and other systems. Making that measurement was an impossible job then. Today, it isn't. New sensors have appeared. Papermaking is becoming more automated because it's now possible to measure a wide variety of parameters in real time. When you measure, you know. And when you know, you can control.

Therefore, production engineers have embraced the digital computer and the new sensor systems for production auto-

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mation, process control, and quality control. I'm sure IBM never foresaw that many of their PCs would end up in industrial usage on the factory floor. These machines weren't designed for that environment, but clever people came up with mods and add-ons that solved the problems.

The advent of the personal computer and the microprocessor has given both scientists and engineers the ability to obtain what we used to call "wall-to-wall data."

The philosophy behind wall-to-wall data is straightforward: If you can measure it, do so. You might—just might—need that piece of information even though you don't know why.

Never mind whether or not the measurement and the data really have anything to do with the final results.

Here's an example of what I mean:

Back in the 1950s, I was involved with the acceptance testing of the Redstone liquid rocket engine that produced 75,000 pounds of thrust. It was an Americanized V-2 engine. For acceptance tests, we acquired 180 channels of data—pressures, temperatures, forces, turbine speeds, etc. That was sufficient to flight qualify a rocket engine that was used to propel the first American manned space flights. Alan Shepherd and Gus Grissom rode in front of that rocket engine.

Today, the Space Shuttle Main Engine (SSME) is static tested at the Stennis Space Center in Mississippi. When the shuttle Orbiter touches down, it's automatically decertified for flight. The three engines are removed and sent back to Canoga Park, California. There, they are torn down and rebuilt by Rocketdyne. Each engine is then sent to Mississippi for re-qualification acceptance testing. This requires nearly 2,000 seconds of hot firing.

Once each firing, 1,400 channels of data are recorded.

Some would say that the SSME is a far more complex rocket engine than the Redstone, that it uses a different combustion cycle, that it pushes the state of the art, etc. The SSME was designed with 1960s technology while the Redstone engine used 1940s technology. So more data needs to be collected on each static test. However, both rocket engines are liquid bi-propellant engines that are regeneratively cooled and turbo-pump fed. Why does the SSME require nearly an order of magnitude more data channels?

I think it's probably because of the engineering equivalent of the Mount Everest Syndrome: "Because it's there!"

Is it because the technology and the funding were available to permit the engineers to take 1,400 channels of real-time data? I seriously doubt that all the wall-to-wall data is really needed. Yes, the computer makes it possible to digitize the data for computer data reduction. In fact, computerized DR is a must. Who can possibly look at 8,400,000 channel-seconds of engine acceptance test data, analyze it all, determine interactions, synthesize and integrate it, and then give a green light for a shuttle launch within six months? On top of that, two engine sets are required for each shuttle launch because a complete spare cluster of three acceptance-tested SSMEs must be at the Cape for each shuttle launch. So we're really

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talking 16,800,000 channel-seconds of ground test data per flight on the rocket engines alone.

This doesn't count the channel-seconds of in-flight data that are taken and recorded.

The Redstone required only 19,200 channel-seconds, and people rode on top of that engine, too.

(Seems to me that the shuttle is powered not by rebuilt engines but by well-used ones. After more than 2,000 seconds of acceptance testing, the actual mission consumes about 800 seconds. Then the engines are torn down and rebuilt. Only 28% of their effective service life is left when they light the candle on the pad. Put it this way: Would you buy a used car with the expectation of putting 50,000 miles on it if the engine had already been run 175,000 miles? In fact, would you even take it for a test drive if its reliability was 95%, which is the target reliability for the space shuttle?)

But the aerospace industry is obsessed with the principle of redundancy. This isn't a totally bad approach. If a critical system goes toes-up, the backup will probably save you. If not, just hope you're one hot pilot like the United Airlines veteran who got the crippled DC-10 on the ground at Sioux City, Iowa after the backup systems failed, too.

And because the aerospace industry has turned into the training ground and depot for high-tech engineers who get laid off due to program cancellations, and end up working in a shoe factory or a book bindery, the principles of redundancy and wall-to-wall-data have percolated into the prosaic low-tech side of industry. This eventually shakes up the low-tech industry where people have been used to operating successful processes making successful products for decades. Suddenly, a gym sneaker that sold for $5 becomes a Reebok that goes for an order of magnitude greater chunk of change. It's a good idea to shake up old, established, low-tech industries. Better products are usually the result.

But not always.

Not if the transplanted engineers insist on taking wall-to-wall data during product development, testing, and quality control.

Did you ever stop to ask yourself, folks, just where all that data goes once it's taken, much less after many man-hours are spent reducing and analyzing it?

Taking wall-to-wall data isn't totally bad. It reminds me of the old saying: "When in total ignorance, try anything and you'll be less ignorant." When you haven't really tested something before, it's probably a good idea to get as much data as possible. But, once you separate the important from the trivial, is it really necessary to over-instrument the production lines? Does it make a better product possible? Is it cost-effective? Does it improve the quality of the product and thus lower the wastage, returns, or customer complaints?

Or was your original intent to use those piles of chart paper and printouts to insulate your house, provide erosion control in the back yard, or cover up the acid stains on the walls of the lab? ■

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The forest was young when humanity was old, and now the forest was old, Tohn thought as he descended the ancient sky bridge between the moon Deimos and continental Tharsis. The great volcanoes had weathered rapidly; he could see a chaos of crags and valleys where once the great crater and lava shield of Ascreaus Mons had stood. It had still been recognizable before his trip to Andromeda. There would be no more where it came from, he thought.

He felt sadness, the chemical heritage of a voluntary, stubbornly determined, living fossil. A moment of mirth at himself, brightened him. He accepted feelings, even knowing whence they came: the exact evolutionary pattern, the type of environment that had conditioned them, however inappropriate. He accepted and enjoyed them in the way of his ancestors, and even he, would still take the trouble to build a wood fire in the wilderness with much better means to warm themselves at hand; for racial nostalgia, for remembrance.

Kairl, his companion for the last few millenia, was somewhere down on Mars, fleeing not him, but perhaps life itself. Her ancestors had come from the planet growing below him. Increasingly distracted, she had left suddenly for home, and he had come to find her. The old way, searching in person; for the Mind of Mars, which included her parents, would honor her desire for privacy. But it would also honor his need by not interfering.

The terminus was a well maintained recreation of colonial Mars, and, conforming to the chronology of the setting, he used the ancient phonetic language with the automata who served the terminus. He located the sporting equipment dispensary.

"Morning," he beckoned a slender golden-haired work of android art in a simple blue robe, sitting cross-legged among stacks of eldrich outdoor paraphernalia. She was actually sewing something. "I'll need a set of wings and goggles. I've come hunting."

"Ha!" she chimed in a clear soprano, and displayed a screen fastener, apparently just reattached. "Could I interest you in a freshly repaired tent as well?"

His current body was a conservative genetic design, but even so, if he chose to sleep he could do so naked in the snow without discomfort or physical risk. He wore a jumpsuit for social convention, to conserve energy, and for the convenience of pockets. He respected form, but he had not come to simply indulge himself in anachronisms like setting up tents.

"Only slow me down, I'm afraid."

She raised blond eyebrows on a high-cheeked, Slavic face. "Wow, so we're on a mission, are we? Are you natural enough that it might be a woman you're hunting?"

"Indeed, yes. She might be about to make a decision from which I wish to dissuade her." And if he was too late, perhaps join her. Wondrous as they are, galaxies, like Beethoven, can bear only so much repetition. How long could *he* go on, just on philosophy and will, when everything was melting away?

After four million years his first long-term partner, Ellincy, had joined the Mind of Preathe, her home world. It had been time, she told him, for a change. But she would always be there

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for him, her mind at his call. She would always care, always remember. He sent love to her now, knowing the mind of Mars would pass his message on, to reach her ten thousand years from now.

"*That* decision?" Golden Lady sighed. "You must mean Kairl DiTensio; she was through here three months ago, talking of a last walkabout in the flesh. She headed for the Syrtis hills on foot. Here, these will do nicely. They're a good compromise between racing and soaring."

Yes, a good choice of wings. He called forth memories, and waited some milliseconds as details he had left with the Mind of Mars returned to him. Um, the harness goes on *so*. Handgrips and elbow sockets needed adjustment. He put a primitive but efficient headband in place and the feeling of having a tail returned. He folded it down from his back and touched the floor a couple of times in experiment. Fine. Golden Lady helped him adjust the handgrips; the last user had longer arms. In doing so she brushed against him, making him think that perhaps she wasn't part of the artificially recreated setting after all.

Are you? he thought, anachronistically forgetting to speak.

"*Natural human? Oh yes, mostly.*" She smiled, making adjustments, tugging here and there on various straps, and continued aloud. "I liked doing this so much that I made a few changes, so that I could like it forever. I don't get bored."

Then, like most others, she had taken one small step away from human nature for eternal happiness. But apparently a smaller step than most; she was still flesh and blood. "How long since you've been on Mars?"

"About eight million years. I returned to Milky Way about five millennia ago with Kairl. I met her at a supernova party in Andromeda, and we found we were both from the home system, if you can believe that. I was born at Maxwell City, 405th century: Tohn Burken Lloyd-Wu."

"A couple real old timers we are! I was doing Boreal Ocean cruises then. Windjammers from Dumont before the Chryse Sea silted up. Back when Andromeda meant a constellation as well as a Galaxy." She shook her head. "Turn around and both the language and the sky change on you. I'm Demia Graves Ostenson. Welcome to Mars in the 102,307th century! . . . Uhm, I think you're all set now. Ten minutes on the air fountain to get your reflexes back. Rules, you know."

He grinned in anticipation. Flying was fun, and he hadn't done any since Wondersphere, on their way back in, three thousand years ago. Though the air was more dense, gravity was almost four times higher here. So the wings were lighter, larger, and more sophisticated, with all kinds of artificial sinews and lock position to ease the strain.

She sighed and touched his arm. "Stop by when you have more time." Her invitation had no urgency, but promised a warmth of companionship.

"Uh, we might do that." He nodded and headed for the air fountain.

People, he remembered as he went through the ancient passageways, had built the original version of this handicapped with unmodified fertility, undimmed sexual and territorial urges, and short lives. Biological immortality

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in the twenty-fourth century had required a drastic lowering of the birth rate. Not to zero; accidental deaths still happened and could be replaced.

But for millions of years, voluntary discorporation, usually to join the great cybernetic planetary minds, had reduced the living population faster than it was being replaced; Mars was almost empty now. People, eventually, got bored. He and Demia were unusual, she the more so. At least six million of his ten million years had been spent in transit stasis. She had been apparently active here, the entire time. He would have to ask about her modification; she had somehow edited boredom from herself without compromising a vital personality.

His thoughts went to their ancestors: imagine being internally compelled to mate, men irrationally risking life and fortune like stags in mating season! And the risks of pregnancy for the ancient woman! And yet they had built this, distracted every time they looked at each other, losing their lives minute by minute, each doing a little and passing it on. In the light of his inner mind, the spare squarish panels and glass of the terminus took on a heroic majesty.

In his travels among seven galaxies, only a dozen races had climbed out of their evolutionary muck. Humanity was a wonder.

He jumped into the air fountain. The reflexes returned rapidly; wings, arms and tail soon moving in effortless coordination to grab and thrust air, then to soar. When he felt fully confident, he feathered and lit back on the edge of the air fountain. He then released and restrapped his wings for practice, and everything was just right.

He checked out a pack, some large comfortable shorts with large comfortable pockets; fish hooks and line, some high energy rations to save him the trouble of hunting and gathering en route, a canteen, and a set of nested cookware.

He also took a compact multisensor, a directional imaging scanner using a variety of wavelengths longer than visual. An imitation of a 400th century device, it was compatible with his genuine 400th century neural interface. He could close his eyes and see what it saw. The Mind of Mars would not deny him communications or navigation, but he would have to find Kairl himself.

Then, wings restrapped, he was back in the air fountain and out the top. Eyes closed, he spotted the infrared tower of air that was a thermal updraft, and with firm hard strokes arced toward it. He caught it and spiraled up ten thousand feet over the tortured badlands and eroded basalt. Eastward, toward Syrtis, he spotted another thermal and glided toward its base, thinking of Kairl. A full bodied woman whose jet black hair hung long and straight past her waist, she was both impulsive and mysterious. Often she did not explain, but just *did*.

As they had approached the Solar System, she had become increasingly tense and distracted. When they arrived, he had gone to the comet museum off Persephone to gain the perspective of distance on Kairl's moods and to renew his acquaintance with history.

The *Pioneers* and *Voyagers* were there, along with the one surviving sphere of the original *Beamrider*. He had spent a silent hour with the husk of Halley's Comet, long since retired from

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its blistering sunward journeys. Measured in generations, in the number of lives, it had seen far more human history than he had. If it could only tell him! A hundred of his fellow living fossils had been there, at what had become somewhat of a shrine at the gateway to the Solar System.

Kairl had stayed behind to bask on the dwarf planet's bubble-enclosed surface in the warmth of the gigantic Persephone reflector and when he returned a month later than planned, the message had been waiting for him. She had left for Mars, the pull of home stronger than a relationship which was only a few thousand subjective years old. He followed immediately; he was losing her, humanity was losing her; he could feel it.

The next thermal brought him to the lakes and marshes that dotted the basin of the former sea. A punishing journey on foot, he thought, suited for one who was feeling self-destructive. For Kairl was in the crisis that took so many people, the crisis of lost purpose, of meaninglessness.

And a dangerous journey. The speed and muscles of a human of his design could easily overcome a single bear, but there were things which hunted in packs. From the sky too, he remembered and looked around. What's out there?

Those hunt at night, the mind of Mars reminded him, unbidden, but perhaps he had subconsciously transmitted that last question in his mind. Fear would trigger that.

In a day, he crossed Chryse, now a plain of forests and lakes, coasting from thermal to thermal. In principle he could have continued, and night was a good time to hunt. But also a good time to be hunted, and with his attention elsewhere, he was an easy mark. In the twilight he stooped toward a clearing among the redwoods on the slopes of the ancient plateau. A stream ran nearby. About fifty meters away was a high bare spot among some large stones. A good camp site.

He hung his wings and pack from a nearby tree and gathered kindling. At this latitude, he was in the lee of the Martian trade winds and things were fairly dry. A thick, dry, downed branch shattered nicely into small logs when he struck a sharp boulder with it. He made a little log cabin of kindling and logs, stuffing it with dry leaves and twigs. He moved the smaller stones into a circle to contain the fire to be.

A movement in the brush caught his eye. Dog sized, but it moved like a squirrel. Belatedly, he asked the Mind of Mars for an update on Martian wildlife. A lot can happen in five million years. Large descendants of the gray squirrel; what he had seen moved with equal ease on two or four legs, and had developed an omnivorous diet and simple tool-using behavior. They had retained their large incisors.

Then he looked at his fire to be. And realized he had brought nothing to light it with. Laughing to himself, he took one of the mini-logs and dug a hole in its side with his camp knife. Putting the whittlings back in their hole, he took another stick and was about to start spinning it when he had an idea.

His 400th century model brain came with its own fifty watt directional microwave transmitter. He took a fish hook,

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put it in his hole of chips, and shouted at it, *burn, burn, burn*. Anyone in receiving distance would wonder what he was shouting about, he chuckled.

But nothing happened. He reached for the fish hook in disappointment—and dropped it immediately. Hot. So it was working. Now, if he could only keep this up. Ten minutes later, much more exhausted than he would have been if he had simply twirled his twig, he had a small blaze going. He was congratulating himself when the first rock hit.

He threw it back, harder, and heard it ricochet off trees like distant gunshots. He pegged a few more in the general area, then remembered his sensor, hanging on the tree with his pack and wings. On a hunch, he shut his eyes to see through its lens. Just in time. Small furry paws were grabbing at it. He opened his eyes and charged with a yell. They vanished. He took his equipment down and moved it closer to the fire.

OK, Mind of Mars, let's stop playing games, he transmitted. *Did Kairl make it through this far?*

Kairl very firmly told us not to interface.

What does that mean? Is she still alive?

A pause. *Yes. For now. She says she will see you. She is here.* A topographic map appeared in front of his eyes, and he recognized the basic features. She was less than twenty kilometers away. *But you must hurry. And be very careful yourself.*

He had his wings on in two minutes, and with a leap that bore witness to conditioning as well as genetic engineering, was aloft. *Tohn?* Her voice was distinctive in radio as audio.

Yes, Kairl. I'm on my way.

This is the way it is. The squirrels have me and I don't want you to interfere. It's futile anyway. I was observing them, and saw one of them kill and start eating another's baby. I interfered and they've injured and cornered me. Don't be shocked. I think that I can hold them off until you get here, to say goodbye. I know how you feel about life and I really feel bad about Persephone. But I had to make the break then.

He stroked hard, skimming treetops half a kilometer above the ground. *Hey kid,* she was less than a tenth his subjective age, *we've been through a lot and made it. We'll get out of this too. Just hang in there.*

No, Tohn. I'm going to join the Mind, with mom and dad and the rest of the family. I'm sorry to disappoint you, but it's what I need to do. You know, this is really an interesting way to go, not boring at all. I'm returning my body, nourishing our successors. I don't think I could have planned it so well.

Then he was there. Nothing but treetops, but he could hear squeals and thumps. He stooped through the branches in a sparse area, protecting the wings with his body. He broke through quickly and cleanly and broke his fall with wings locked open, composite fiber sinews taking the strain. Then he glided past the trunks a hundred feet above the ground toward the noise.

In the sensor, in the near infrared, the scene was almost as clear as day. Kairl, her hair glowing with warm blood, backed into a notch of rock, the carcass of a small supersquirrel at her feet, was fending off twenty or so adults with a

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stout branch. She was being stoned and bleeding badly. She had one leg.

See, her voice laughed, *if I really were an old style human, I'd already be dead. But my arteries close, my bones don't break easily, and I can shut off the pain. It's great theater, isn't it?*

You will regenerate if I can get you out of there, he pleaded. *Please!*

No, don't try. I am going willingly. This is getting tiresome, and I'm hurting them. I'll have to continue this conversation as part of the Mind of Mars. Talk to you then.

As he watched helplessly, she stopped fending them off and walked toward them, using her stick as a crutch. There was a pause as they momentarily recoiled, and he struggled toward her, the Martian air viscous to his accelerated time sense, hoping to snatch her like an eagle from that small clearing around her.

She saw him, grinned, waved and yelled "goodbye" in the mellow burbling music that had graced his life for the past five millennia. A rock struck her head and she crumpled. The stump of her leg bled freely. Then they were upon her and he on them. He screamed, and a few looked up, but most were too busy with their bloody incisors.

It's too late, she laughed, *I'm here now, in the mind of Mars, on Phobos. I'm fine. It's wonderful.*

"But it's not human!" he screamed in both ways. More supersquirrels looked up. So they're sensitive to that? What might be in their genes, he wondered? He remembered his fire-starting technique, and circled, concentrating on a feeder. It put its hands to its head, and fell. He moved to the next one. It fell as well. Too effective, the others didn't notice.

On the third one, he backed off a little. It reared up and squeaked in terror and the others reared up too. He was conscious of spending his energy at a fantastic rate, flying and shouting. He could now see what was left of Kairl. A supersquirrel went back down to it and he hit it with a furious microwave blast.

Confused, they avoided Kairl's body, but some moved to the carcass of the youngster. He hit those too. Irrational, pointless. There was nothing to save.

And suddenly, he felt weary beyond measure. With the last dregs of his hysterical energy, he flailed to a stout lower limb of a great tree, some twenty meters above the forest floor, managed to hang on and hoist himself over it, gasping.

Too tired to move, he noticed, almost disinterestedly, that some of the smaller supersquirrels had waddled over to the base of his tree. One of the smaller supersquirrels moved over to the small carcass, which the others now avoided, and pushed at it. *Its mother?* Tohn asked.

Yes, the Mind of Mars said with Kairl's voice. *See, they are gray colored, and the others have a reddish cast. We think she was captured and mated. When her child didn't look like the others . . . Well, I was stupid to get involved,* she declared with the authority of the ten-million-year-old cybersapient of which she was now part.

You were human, Tohn replied, bitterly emphasizing the *were.*

The Gray moved to what was left of Kairl, and pushed at that, too. It avoided the Reds that Tohn had killed.

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It looked up at him, clearly sensing, by smell perhaps, his likeness with the being that had tried to save its child.

Do you think they could eventually be civilized? Tohn sent.

It is possible, but it is certainly a very long-term project, the Mind replied, in its own voice. *This group, despite its behavior, is the most intelligent we've seen. They don't have fire, but some of the stones they throw have been edged, by them. They understand sticks and use them for a variety of things, including as a lever.*

Their social organization is simple domination by the most aggressive member. Genetic analysis shows that at some time in the distant past they received some human genetic material, perhaps as part of a medical experiment. Our knowledge before the twenty-fifth century is not all-inclusive. Also, there has been a lot of environmental change here, operating on ten million years of genetic drift. We suggest you conserve your radio voice; it's very faint now.

Worn out, Tohn thought; everything was so old. The Sun had grown so that old Earth, like Venus, needed a sunshield. A year was no longer a year: for the past six million, giant solar sails had sat alongside Mercury, Venus, and the Earth-Moon system balanced on solar pressure and tugging the planets gently, persistently outward from the growing Sun with the thin elastic of gravity.

A tug on his leg brought him back to more immediate concerns, and he irritably jerked his leg away, momentarily pleased that he could move it again, though the effort exhausted him. Then he stared at the cause of the tug with a hint of fear. One of the Reds had climbed the tree to reach him, and he was still very weak. Free for a second, he pulled himself about a meter farther out on the branch, his arms clearly telling him that neither fight nor flight was possible just yet.

A confusion of motion and squeaks erupted, and a gray furball appeared between him and the Red. Squeals and blood. The shock of events cleared his mind, and he belatedly thought of his rations. He managed to get some from his pockets and stuffed his mouth. It would take minutes for them to do him any good, but better later than never.

An idea. He waited for a lull in the battle of the branch. The Gray had assumed an effective defensive position, and the current Red on the point was hesitating. He got the Gray's attention. It almost snapped at him, but stopped just in time. He bit a chunk off the ration bar and held out the rest to the Gray, who took a hand off the branch without losing its balance, and quickly stuffed the bar into its mouth pouch. It flashed its incisors at a non-serious lunge by the Red.

Another idea. He got the Gray's attention again and showed it his camp knife, slicing a piece of bark in demonstration. The Gray got the idea immediately, and even gave a short chirp. It took the knife and held it in its hand easily. The next half-hearted lunge by the Red earned it a split nose. It emitted a squeal from hell and deserted the point position.

Its replacement didn't lunge. A standoff.

The gunshot startled him and the Gray shivered in terror, but turned to

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face the new threat. Two more shots and the Reds were running. Tohn found he could move now, and hoisted himself around, straddling the branch like a saddle. Thus secure he looked around.

A blonde Valkyrie wearing exceptionally thin jet-black wings appeared and flew to the trunk, sticking in a maneuver that would shame any cat or woodpecker.

"Think we can persuade your lady friend to put down the knife?" Demia asked.

With fire and the ancient gun to keep the others at bay, they camped near the battle site for three more days. What remained of Kairl, a body which had lived ten times longer than any of the trees around it, and which was destroyed by semi-sapient barbarians in a few minutes, was burned with reverence, as was that of the fallen Gray pup, possibly less than a Martian year old. Somehow, the Gray mother seemed to understand this, and looked up with them as the smoke wafted skyward. They moved the bodies of the fallen Reds some hundred meters away and left them for the ravens.

Servants and eyes of the Mind of Mars, they could taste the fruits of its noninterference policy.

The Gray permitted Demia to treat its wounds, and then, surrendering all caution with the humans, let itself be stroked and hugged. There was almost an erotic delight in doing so, in which all three beings indulged themselves. The Gray purred, like a cat.

Demia was impressed by the novelty of Tohn's fire-starting technique, though not by its efficiency. She was even more impressed by its effect on one of the occasional Red intruders.

"The bioelectronic array was built from genes from the visual system," he told her. His grandfather had been on the project, so its details were part of a memory he always carried with him. "Morphologically, it's like a huge retina behind the forehead. If I focus my eyes on a target, and then think of transmitting *through my eyes,* instead of *at* the target, I get the best concentration."

With practice, Demia was able to master the technique. "Has anyone ever done this before?" she wondered aloud.

Not on Mars, or in any other of my records, the Mind answered. That covered a lot of space time, but not everything.

"Well, that's close enough to new to excite me!" she exclaimed. "See, we'll never be old enough to know everything!"

Later, with Tohn's energy restored and the Gray's wounds healed, they flew escort for her back to her own territory. Among her own kind, after some wary wiggling of noses, she scampered back into her burrow, then popped her head out and sounded what Demia and Tohn now recognized as a happy chirp. They waved as they flew off. They went south to the equator for strong westerlies, then west toward Tharsis.

Now I have something new to show you! Demia radiated as they soared along. *Actually, we've been predicting it for some time, but the first evidence showed up only the day you left. It's why I went after you; I thought it might help convince Kairl to hang around a few more millennia.*

Whether you like to believe it or not,

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I'm still here, cruising over your heads, the Mind told them in Kairl's voice, *and if you want to see something else new and exciting, look to the west, on the cloud deck.*

Tohn saw a dark spot moving toward them with the deceptive slowness of distance. But it would reach them in minutes. "*An eclipse!*" Excited, he shouted in both ways. "*I think we can catch it if we fly south a little more.*" They did so, then turned back east and gained as much altitude as they could. When the first hint of shadow reached them, they dove, getting as much eastward velocity as possible. When the air turned cold and the sky black, they looked up.

The corona shone. The blue and gray double star of Earth-Moon shone and the brilliant white of Venus.

There's Sirius. Demia broadcast. In whatever new constellation, Tohn thought.

Look, to the left of the Sun; that must be Mercury, and its solar sail.

Yes, I see it.

Ouch, look away. A brilliant bead flashed into photosphere on Phobos's racing limb. Totality had only lasted a few seconds. *Well, I'm impressed,* Tohn declared. *Just how long has this been going on?*

Only for the last few centuries, the Mind of Mars replied, *and you couldn't see it from the surface; Phobos hasn't dropped quite low enough yet. I'm going to maintain its orbit with an electrostatic jet when it's low enough to provide a good show at the surface.*

Will wonders never cease? Tohn meant his question to be rhetorical, but Demia answered anyway.

Just wait until tomorrow. We can be over the Olympus Badlands by early afternoon. They turned northwest.

Badlands, he thought. It was one of the great mountains of the Solar System when he was last there.

A river meandered through the long low depression still known as Valles Marineris, and interestingly, several bends had been isolated, cut off by changes in the river course. They camped that night on the river shores. Demia caught a huge catfish and they dined well. Still recovering his reserves, Tohn slept soundly and dreamed that he was so dead to the world that Demia couldn't even shake him awake.

It was actually just after sunrise the following day when they approached the old mountain, having stopped on impulse at the museum of Port Lowell. The circular outline of the badlands betrayed the location of the ancient shield, and a cluster of impressive hard basaltic towers betrayed the location of the old crater. They were shrouded in mist rising from the pools of water which had collected in hollows between the old plugs.

"Don't touch the water," Demia warned him after they landed near the base of a ten-thousand-meter monolithic plug of fossil lava. Then it hit him. The water wasn't misting. It was steaming.

"It's active! But how?"

Her laughter rung in chains.

"There's still a small planet's worth of radioactive decay going on inside Mars, and will be for billions of years to come. It has to come out somewhere. And we've suddenly changed the hydrostatic balance with so much erosion. The land under the old mountain is lift-

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ing again, some places a centimeter a year. It's cracking and rubbing against itself. All sorts of friction. Didn't you feel the quake last night?" She pressed herself against him.

The ten-thousand-meter tower next to him was considerably taller than broad. He looked at both it and her apprehensively.

"I've changed myself, yes," she said, "in some respects, a little way back to what we were before. I think there are too few real people in this universe now, don't you?"

"Well, yes." That was his philosophy, his reason for continuing in the face of six million years of repetition. "But I'm not sure what the point is anymore." He thought of Kairl.

"The point! Look around you! Does there have to be a point to this? It's wonderful. Don't tell me it's not—I saw that look in your eye, at the eclipse, at the steam vents. Tohn, we are the first people to live long enough to see the long pulse of nature. We can see a species evolve toward sentience. We can see the land boil and flow. Change. Rebirth. You can watch the majesty of it unfold and it fills you, or you die.

"They're dead now, or gone, those who weren't filled by it. We're the new race by virtue of surviving." Demia laughed. "We can watch the Solar System as the Sun grows and the planets move out, we can guide new species to sapience, and see the stars swirl and dance in the Milky Way." She took his hands and looked up at him, all brilliance and determination. "The squirrels have a long way to go. I think we should populate this world again, now, with people like us."

Something she was doing, something she was sending out, infecting him with, or body language perhaps, maybe smell, was making him feel things he hadn't felt for ages. Her hands were on him, removing his clothing. He didn't mind. He laughed, kissed her, and released the front of her jumpsuit. Unnecessary things fell like dry leaves at their feet as they embraced among the now stirring bones of ancient Olympus Mons.

"It's a spring morning and I can love you like no one has loved for millions of years," she told him when they rested. "We aren't old; the stars are old. We're young. We are ten-million-years young and it's all just beginning." The planet shuddered in agreement, and some rocks fell in the distance. He looked up. ■

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Probability Zero

DOING SOMETHING ABOUT IT

Stephen Walton

Everyone wants to change the world, but the real reason we came up with the pari-mutuel weather scheme was to make a buck.

Fred and I were both out of work, and we used to meet at my apartment because I had the better computer and the laser printer.

"What about the weather?" I asked.

"Yeah, pretty nice day." It was in fact a gorgeous day in late April, and although Fred would rather be out golfing in any weather, he had come over to answer job ads and talk about what we could do for *real* money.

"No, what about *doing something* about the weather? About predicting it?"

"Too tough, Jack. You've read about chaos—too many perturbing factors. A butterfly sneezes in Cleveland and you get a typhoon on Taiwan." Fred may be an avid golfer, but he's not a complete idiot.

"I agree that deterministic prediction methods are doomed to failure, but maybe there are nondeterministic methods that could be used to advantage. Intuitive methods."

Fred shrugged. "Then it's a guessing

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game. It's anybody's horse race."

Three-second pause, then brilliance on my part:

"It's *just like* a horse race," I said. "Where the final odds represent the collective considered judgment—or intuition—of a lot of people who make a rather intense study of the entrants. And then demonstrate their commitment to their conclusions with money."

"And the collective opinion," Fred continued smoothly, "while not perfectly predictive, is probably correct more often than the dismal average generally achieved in professional weather forecasting."

"So if we get people to bet on the weather," I said, "they will gradually get better at predicting, until the favorite amounts to a pretty reliable forecast for the day. Because the people who bet it right are going to split the pot."

"After we take our percentage."

"After we take our percentage," I agreed.

"Pari-mutuel forecasts. Hmmm . . . Pari-Weather . . . "

"Off-cloud betting?"

"Favorite forecasts . . . You-Bet Weather . . . "

"U-Predict Weather. With a Capital U. 'The forecast you can bet on.' "

"Yeah. That's OK."

"And besides the betting handle, we also sell forecasts to radio and TV."

"Novelty at first. Give 'em a couple of months free. But how are people supposed to place their bets? New York State and City aren't going to give us space in the OTB parlors."

We thought for a long time. Then Fred smiled and said, "Nine-hundred numbers. They call nine hundred whatever to place their bets. Two dollars a call. Call as often as you like. Select via the touch-tone keypad. Predict right and we mail you a check."

"Of course."

And we were off.

The launch went smoothly, considering. The rapid relocation of our headquarters to Reno, Nevada, got the attorney general to drop his charges. But the New York metro broadcast stations didn't care where we hung our hats, so long as we kept providing the most accurate weather forecasts they had ever had, and we were getting into other markets at the rate of one a week. The long-distance company was doing the real work for us. Fred had found some fine golf courses around Reno, and I was adjusting.

Things didn't go wrong until November.

"Remember Tim Miller at WRGB?" Fred asked before I could even set down my clubs.

"Albany."

"He says we haven't been right yet this month. Not once. He's concerned."

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"Well, so am I. But that's the kind of statistical variation we have to expect from time to time. Isn't it?"

"It's possible," Fred admitted, "but it's *awfully* unlikely. Like about a point oh oh one probability."

It was embarrassing but true that we had noticed no problem with the Albany forecasts. But we never lost money when the favorite failed to win—we just took our usual handle and split the remainder of the pot among those who had bet right. We spent the rest of the day and six hours into the night developing the analysis we should have had all along.

"The other markets are all OK," Fred announced after going over his spreadsheet again. "We're still beating the National Weather Service four times out of five every place else."

"I'm getting a nasty feeling about this," I said, looking up from the figures on my own screen and the slice of cold pizza in my hand. I had been going over some of the detailed reports from AT&T—data we had never properly examined before. "Give me another minute."

But the pattern in the results proved inescapable. I sighed. "This could actually be good news, in the long run. We can find the person involved and make him or her our partner in a larger enterprise. OK, we always structure the betting field the same way, though we vary it for locality, climate, and season. There are always a few forecasts that we consider most probable, based on past experience, the *Old Farmer's Almanac* and NOAA's predictions. Then we add one or two extreme possibilities, because lots of bettors love long shots."

"Yeah, yeah."

"The records for Albany this month show that the winning bets have paid high odds, because they have *all* been on extremes."

"There *was* something on TV," Fred said, "about Albany having subzero temperatures one day and thunderstorms the next."

"Mm-hmm. Well, we really have to congratulate ourselves. When we started this business, we intended to bring about a significant improvement in the accuracy of weather forecasting. Which we did."

"Except in Albany."

"Because we succeeded beyond our expectations. Not only did *we* do something about the weather, we also inspired someone else to do something about it—something an order of magnitude greater."

"Uh-*huh*." That was Fred catching on. He's really pretty quick, for someone who's both an inveterate golfer and a natural blond. "Our potential partner in a *much* larger enterprise. We inspired somebody to do a *lot* more about the weather. We inspired somebody to *fix* it." ■

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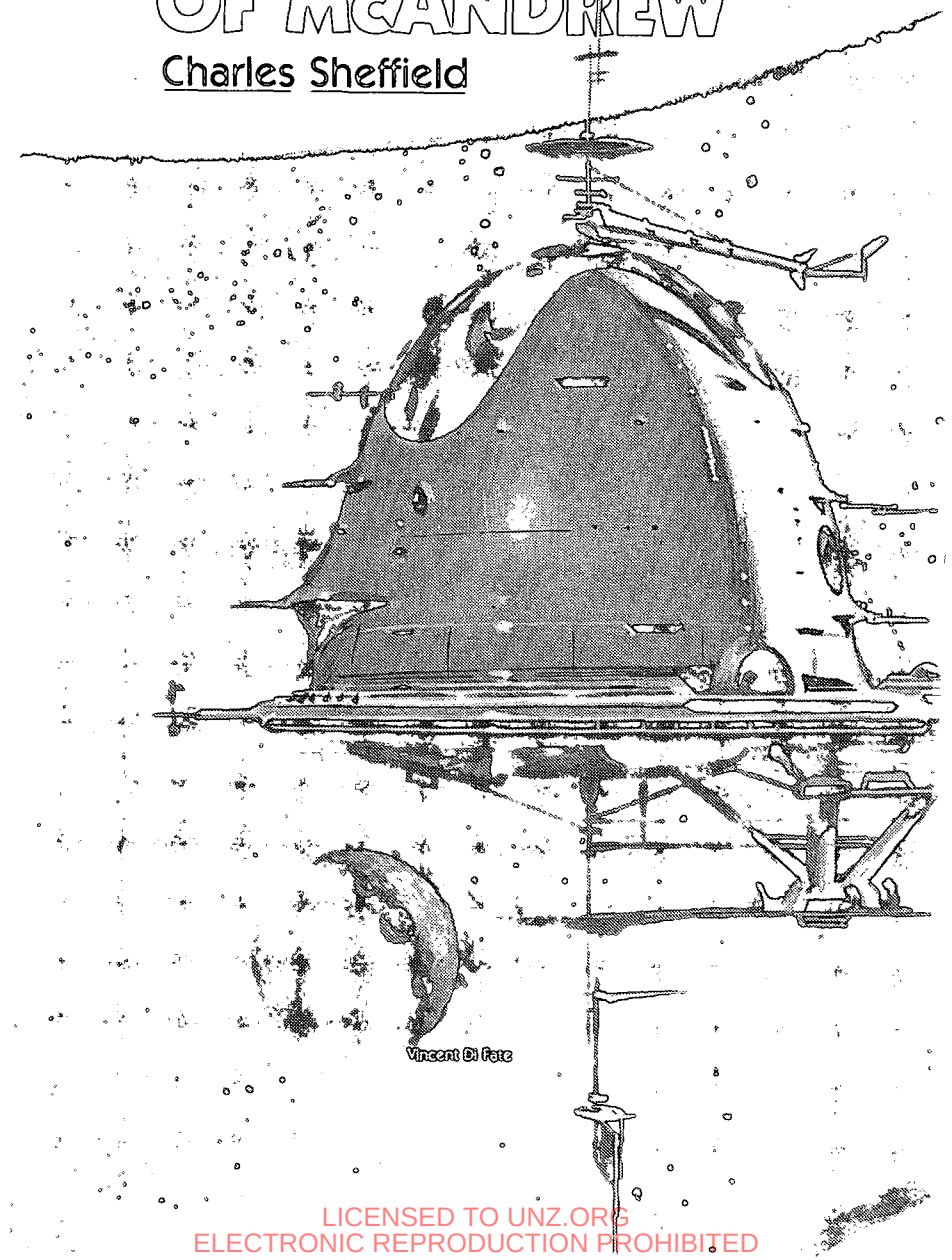
THE HIDDEN MATTER OF McANDREW

Charles Sheffield



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The message was concise and clear:

Dear Captain Roker,

The Institute is sending a party to explore a region approximately half a light-year from Sol, for the purpose of verifying dark matter conjectures in current cosmological theories. Our projected departure date is six days hence. Knowing of your experience with Hoatzin-*class ships employing the balanced drive, we wonder if you might be available to serve as a crew member for Project Missing Matter. If you are interested in so serving, I invite you to contact me or Dr. Dorian Jarver at the above address.*

Sincerely,
Arthur Morton McAndrew,
Research Scientist,
Penrose Institute.

Clear, but also totally baffling. It was no surprise that McAndrew wanted to test obscure scientific theories. That was his stock-in-trade. People who knew physics as I would never know it told me that McAndrew was better than anyone else alive—a name to be mentioned in the same breath as Newton and Einstein.

It was also predictable that he might be heading far out of the Solar System. He had done that whenever he thought there was something interesting to look at, or just when he needed a little time and space for serious solitary thinking. "I have to have it, Jeanie," he'd said to me, a score of times. "It's very nice to work with colleagues, but in my line of business the real stuff is mostly worked out alone."

Nor was it odd that I was learning about the trip so late—a couple of times he had hared off on wild sorties far outside the Solar System, and I had been forced to chase after him and drag him out of trouble.

But now for the mysteries: He had never, in all the many years since first we met, sent a letter to "Captain Roker," or signed himself with his full name. I was always "Jeanie" when he wrote to me, while he signed as "Mac" or "Macavity"—my private Old Possum-ish name for him, because like Macavity the Mystery cat, McAndrew did things that seemed to break the law of gravity.

Second, he didn't *write* when he was planning an expedition. There would be a random call, at any hour of the day or night. He was thinking of making a trip, he'd say vaguely. Would I perhaps like to go along?

Third—a detail, but one that chafed my ego—I was invited to go on the Project Missing Matter expedition as a *crew member*. Mac knew that I'd served as ship's captain, and only as captain, for fifteen years.

Fourth, the whole tone of the letter was too stilted and officious to be genuine McAndrew. He couldn't sound that formal if he tried.

And one more mystery, to round out the set. Who the devil was Dorian Jarver? I thought I knew all the key scientists at the Penrose Institute.

That question was fifth on the list, and the least important until I tried to call McAndrew for an explanation. Then instead of the old direct-access lines into individual offices at the Penrose Institute, I found myself dumped to a Message Center where my call was at once rerouted from McAndrew to Do-

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rian Jarver. Director Jarver is unavailable, said a polite voice. Please leave your name, and he will return the call as soon as possible.

I hung up without waiting to learn if the voice at the other end was live or recorded. *Director* Jarver? What had happened to my old friend Professor Limperis, the blackest man alive, who had run the Institute since long before my first visit?

Finding the answer to that was not difficult. I tapped one of the general data bases and queried for the staff file of the Penrose Institute. Professor Limperis was listed, sure enough—but as professor *emeritus* and *ex*-Director. The new director was Dr. Dorian Jarver, former head of the Terran science applications group, and—bad sign—nephew of Councillor Griss, head of Terran Food and Energy.

Anna Lisa Griss, that was, a lady whose arm McAndrew had once, with the best of possible intentions, cut off with a power laser out in the Oort Cloud. It would have been regrown, long since; but I doubted that the memory had faded with the scar.

I followed an old McAndrew principle, and went to a publications data base. Dorian Jarver was there, with eight or nine decent sounding physics papers credited to him; but they were not recent. The newest one was eleven years old. The new director of the Penrose Institute appeared to be an ex-physicist. McAndrew was anything but an ex-physicist. Why would he cite his own name and *Jarver's* as someone I might contact?

When I received the message from McAndrew I was on the tail end of a routine run home from Titan. As soon as the Assembly I had been piloting was tucked away and all its sections placed in a stable parking orbit, I signed off and headed straight for the Penrose Institute aboard one of the five-gee miniversions of the McAndrew balanced drive.

"I invite you to contact me or Dr. Dorian Jarver," the letter had said. *Contact* can surely include a visit.

The outline of the Institute at last appeared as a lumpy and spiky double-egg during my final approach. I examined it closely. It would wander around the inner Solar System depending on research needs, anywhere between Mercury and the Belt, but its facilities shouldn't change. They hadn't. As we docked I could see the *Dotterel* and the *Merganser* moored in the external hoists. They were the first prototypes using the McAndrew balanced drive (which everyone else, to Mac's intense annoyance, insists on calling the McAndrew inertia-less drive). Those early ships were no longer in use. They had been replaced by a more advanced design, embodied in the *Hoatzin*. I could see its bulky mass plate and longer central spike off in the distance. It appeared slightly grubby and battered-looking, as befitted the first and only ship to visit both the Ark of Massingham and the Oort Cloud.

The changes began inside, as soon as I passed through the lock. In the old Institute the visitor found herself wading at once through a junkyard of obsolete equipment waiting for disposal. It would have been quite an obstacle course in an emergency, but nobody had ever seemed worried about that.

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Now I found myself in a clean and uncluttered chamber. The walls were painted white, the floor was polished grey, and in the middle of the room sat something that the Institute had surely never seen before: a long desk, two receptionists, and in front of them, a sign-in terminal and a tray of badges.

The woman behind the desk went on fiddling with a great bank of controls in front of her, all flickering lights and low humming, but the man glanced up at me inquiringly.

"I'm here to see McAndrew," I said, and started towards the corridor on the left. I'd been here scores of times, and I knew where Mac hung out, in a cluttered room that made even the old entry to the Institute look elegant. Mac didn't throw away junk equipment. He kept it in his office.

"Not that way, ma'am," said the man politely. "Professor McAndrew is the other way now. You will need an escort. And if you'd first please check in . . ."

McAndrew's voice was starting to whisper in my ear. By the time that I had signed in, stated my identity, had my ID independently checked with a DNA mapper, been assigned a badge, and refused refreshments (how long did they expect me to be in the reception area?) Mac's voice was shouting at me. "Help, Jeanie," it screamed. "Help, help, help!"

This wasn't the Penrose Institute that I had known, the place of casual procedure and superb science where Mac had worked for half his life. It had become a clone of a thousand Earthside technology offices.

And it got worse. When I, checked and signed and badged, was led away towards the new working offices, I still did not reach McAndrew. "In a few minutes," said my guide, in answer to my question. "But first, the director."

I was ushered into a new chamber, starkly clean and sparsely furnished. My guide left at once and I looked around. There was no desk, no terminal. Over in one corner on an angular white chair sat an equally angular and thoughtful man, fingertips touching in front of his face.

"Captain Roker," he said, and stood up. He smiled, very white teeth in a thin-lipped, worried countenance. "I'm Dorian Jarver, the director of the Penrose Institute. I must say I didn't expect a visit until you'd heard more about the project, but it's a blessing that you're here, because now we can all do our best to persuade you."

"I'm persuaded already." I realized that was true, and had been since I saw that ritzy new entrance foyer. "I'm reporting for duty right now."

"For the expedition described in Professor McAndrew's letter to you? But the mission and your role in it are not yet fully defined."

"You can define that later. I'm here, and I'm ready to start."

Dorian Jarver must have been surprised at both my arrival and my instant acceptance. "I'm delighted to hear that," he said, though he didn't sound it. "You come to us with the highest recommendations. And I have to admit that I've been a little worried about this proposed expedition. It could be dangerous, and Professor McAndrew is too valuable to risk. He's one of our most priceless assets."

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No matter what else he didn't know, he obviously understood McAndrew. It *could* be dangerous, because Mac would charge into hell itself if he saw some intriguing scientific fact sitting in the innermost circle. He *was* too valuable to risk. But Jarver's final word was disturbing to me. Not a scientist, not a human being. An *asset*.

"You have been to the Institute before?" added Jarver.

I nodded. I didn't know what Mac had told him about me, but I suspected that the new director had no idea how close we were.

"Then you'll have noticed the changes here. The Council had been worrying about the Institute for quite a while. When Director Limperis retired and I came in, the Council insisted that from now on operations would have to be organized rather differently."

He talked about those changes for the next few minutes. Better equipment and facilities for the scientists. Bigger and cleaner offices. More attention by support staff to routine maintenance functions. Removal of the need for top scientists to waste their time on calls and letters and incoming requests for information, trivia that could be handled just as well by junior staff.

It all sounded terrific. But McAndrew's strangely awkward letter stuck in my head. I wanted to see him, and make sure that he was all right.

With my mind on McAndrew as Jarver went on talking, I didn't think that I was saying much in reply. But it must have been enough for the director, because after another few minutes he seemed to lose interest in the conversation, nodded, and said, "Now, Captain Roker, I'm sure you'll be wanting to hear more about the expedition itself. Project Missing Matter will be testing some of the most fundamental ideas in cosmology; of course, you'll get that better from McAndrew than you'll ever get it from me."

As we stood up I thought that I had Dorian Jarver pegged. I had seen him before, many times. Not the man himself, but the type. The upper levels of Terran government were full of them: competent, hard-working men and women, who started out as scientists, found that they were never going to be better than average, and at an early age substituted management and administration for research. Jarver had changed over the years from scientist to calculating bureaucrat.

Well, I've been wrong before. Let's call that my first mistake on Project Missing Matter.

The director led me to an office down at the far end of the corridor, and opened the door. It was big, far bigger than McAndrew's old, cluttered den. It had the same antiseptic look as the rest of the new Institute. But even Jarver couldn't do much about the appearance of the occupant.

McAndrew was lolling in an easy chair, staring vacantly at the wall. His shoes were off, his feet were bare and grubby. His thinning, sandy hair was standing up in little wispy spikes as though he had been running his hands through it, which he tended to do when he was thinking; and I could see from the redness of his finger and toe joints that he had been pulling them and cracking them, in the way that I hated.

He glanced up as we came in, swing-

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ing his chair casually in our direction.

"Jeanie Roker," he said. He didn't stand up, and he didn't seem in the least surprised at my unexpected arrival. I glanced at Jarver out of the corner of my eye. If Mac wanted to convince the director that he hardly knew me, he should have acted quite differently.

"Professor McAndrew," said Jarver to me. It could have been an introduction, or possibly an apology. "If you'll excuse me, Captain Roker, I'll leave the two of you to discuss the expedition. I'll meet with you again later."

As soon as he was gone I bent over and gave McAndrew a six-month separation hug. The hell with formal handshakes. He hugged me right back, then I flopped into the seat opposite and said, "Mac. What the hell is going on here?"

"You saw it already." His face took on a gloomy, give-up expression that I didn't like at all. "New offices, new procedures, all the other folderol. Now tell me, did I *need* a new office?"

"Does it matter that much? You can work as well in here as you could in your old place, and it's nice to visit and sit on something softer than an optical scalar calibrator. And Jarver's right, the Institute was getting a bit run-down. It looks good now. You're becoming crabby in your old age."

He glared at me. "If that were the whole of it, I might agree with you . . . but it's not. You had that letter. Didn't it make you wonder a bit?"

"Why d'you think I'm here?"

I don't believe he heard me. "*Due procedure,*" he said, "that's what they call it. But it's beyond that. No messages or memos or papers or letters go out from here without stamps of official approval on them. You saw how my letter to you sounded after they'd done messing with it. All the incoming mail is opened, too—personal as well as professional—before we get to see it. Spoken messages are just as bad. Incoming and outgoing calls are all logged and recorded. Did you see that blasted bank of equipment in the front area, with administrative staff snooping on everything? I'm telling you, it's like being in a bloody prison."

"Mac, you're overreacting. Jarver is used to running things Earth-style. They're hot on procedure. It'll take him a while to learn Institute ways. You and your buddies will sort him out."

"Will we now?" McAndrew snorted. "Me and my buddies will sort him out, will we—when Emma Gowers and Wenig and Lucky Macedo have already resigned and left."

That was a shocker. I knew all three, and there wasn't one who didn't make me feel, without their ever intending it, about as bright as a chimps' tea-party drop-out.

"Mac, that proves my point. If Jarver's losing high-caliber people like that, he must know that he won't last another three months. Unless he's too dumb even to realize what he's driving away?"

I saw a change in McAndrew's expression. He's the system's most honest man, even when it undermines his own arguments. Now he looked guilty.

"That's maybe the worst of it," he said. "Jarver's not stupid at all. He got the job here, likely, because he's a relative of Anna Griss. She's no lover of the Institute after what I did to her. But Jarver didn't come here wanting to de-

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stroy the place. He's a good physicist, see, with a real sense for what's important."

"That's not what I thought when I looked at his publication record. Not many papers to his credit, and all written a long time ago."

"Jeanie." McAndrew stared at me with the disappointed expression of a man whose dog has slipped back into non-housebroken ways. "How many times have I told you, a publication record tells you *nothing*. Any clod can spew out words and equations, year in and year out, and push them into print. Papers don't count for *anything*, unless other people use 'em. You should have looked at the Citation Index, to see how often Jarver's work is given as a reference by other people. If you'd done that, you'd have seen hundreds of them. He's not publishing now, true enough, but when he did, he was *good*."

Poor old McAndrew. I was beginning to see the real problem. Here was a new director who did everything that Mac disliked, a man whom he would love to hate and disparage. But he couldn't do that. Jarver was a good physicist, and therefore almost beyond censure.

"But if he's that bright, you ought to be able to work with him. *Persuade* him."

"Damn it, I *have* persuaded him. That's what the new expedition is all about. I've got Jarver convinced that we have to go out a long way from Sol. Then we stop, sit still, and do our measurements, and learn more than anyone has ever known about the distribution of missing matter."

I had to find out more about that, but this wasn't the time for it. Half a light-year from Sol was a long trip, even with a hundred gees of continuous acceleration and the relativity squeeze that our high speed would provide us. We'd have weeks to talk about missing matter, Mac's experiments, and everything else in the Universe. But it would be nice to know why we had to go out there at all.

"Why not do your experiments here at the Institute?"

"Because it's too damned *noisy* near in." McAndrew became more like his old self as the conversation turned closer to physics. I decided there was hope—maybe he wasn't a broken man after all. "It's the Sun's fault," he went on. "Sol generates such an infernal din, gravitationally and in almost every electromagnetic wavelength you can think of, that you can't do a decently sensitive experiment closer than half a light-year. It's like listening for a pin drop when somebody's banging a bass drum right next to your ear. We have to go out, out where the interstellar medium is nice and quiet."

"But that's exactly what you will be doing. You'll be flying out on the *Hoatzin*, and as far from the Institute as you want to be. So why aren't you pleased?" I had a horrible thought. "Unless you're telling me that Jarver proposes to go along with us."

"No, no, no." McAndrew went right back to being gloomy. "He says he'd like to, but he's far too busy running the Institute. He's not going. But he's sending his aunt's pet bully-boys, Lyle and Parmikan, along to keep an eye on things and report back. Now *that's* what really has me going, Jeanie. That's the reason I sent you the letter."

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I got very annoyed with McAndrew. He was taking a perfectly natural decision, from Jarver's point of view, and blowing it out of proportion.

Of course, this was before I met Van Lyle and Stefan Parmikan.

The doubtful pleasure of that meeting was not long delayed. It came the same afternoon, when McAndrew dragged me along to the weekly seminar, a tradition of the Penrose Institute for as long as I had been visiting it.

The old meeting room, with its poor air circulation and white plastic hard-backed chairs, had vanished. In its place was a hall with tiers of plushy seats running in banks up towards the rear. It could hold maybe three hundred. The seminars that I remembered might draw fifty, if they were on a really hot subject.

Today there were no more than thirty people in the room. McAndrew and I took seats at the end of the last occupied row. I tried to recognize the people I knew from the backs of their heads. I did pretty well, over half the audience. Wenig and Gowers and Macedo might be gone, but most of the other old-timers at the Institute hadn't given up yet.

The lecturer, Siclaro—another Institute perennial—was already in position and raring to go.

"The first ten-thousandth of a second after the Big Bang is far more interesting than the entire rest of the history of the Universe." That was his first sentence. I couldn't tell you what his second sentence was. I didn't *expect* to understand the seminar, you see, because I never had in the past. But I might still enjoy it. Like the psychologist at the burlesque show I concentrated on the audience, examining the newcomers to try to guess their specialties and how good they were at them.

A futile exercise, of course. Emma Gowers, the system's top expert on multiple kernel arrays, looks and dresses like a high-class whore. Wenig could be her pimp, and McAndrew himself resembles an accountant in need of a haircut and a good meal.

You just can't *tell*. Brains won't correlate with appearance.

Over to the far left of our row sat a group of three. I saw Dorian Jarver. He was leaning forward, intent on the presentation. To his immediate right were two men of particular interest to me—because they too were taking no notice of the lecture and showing a lot of interest in the audience.

I nudged McAndrew, just as someone hurried in from the back of the room and leaned over to whisper in Jarver's ear. He sighed, shook his head, and followed the woman quickly out of the hall.

"What?" said McAndrew at last. He had missed the whole episode with Jarver.

"Those two men. Who are they?"

He snorted. "Them two? Van Lyle. Stefan Parmikan."

I stared with redoubled curiosity. Van Lyle (I found out later which was which) was a big, broad-shouldered fellow with curly blond hair and a handsome, craggy profile. He made no pretense of listening to the lecture, but he observed the audience with open interest. At his side the little, round-shouldered figure of Stefan Parmikan was far more discreet. To a casual observer he

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was following everything that Siclaro said—but every few seconds his head would turn for a moment and his eyes would flicker over everyone. When they met mine, he at once turned away.

"Mac," I said. And paused.

He had slipped away from my side. I saw him down by the lecturer's podium next to Siclaro, one hand pointed at the screen.

"You know the problem," he was saying. "We all believe that the amount of matter in the Universe is *just* enough to keep it expanding forever. That gives asymptotically flat space-time, an idea we have half a dozen good theoretical reasons for wanting to believe. But the bright matter—the stuff we can see—only accounts for maybe a hundredth of what's needed to close space-time. So, where's the rest of it? Where's the missing matter?

"I agree with Siclaro, it's the devil to answer that question from any experiments we've been able to do so far. I wouldn't propose to try. But we've designed a whole new set of crucial experiments that we can do if we are far out from Sol, where there's not so much interference."

He was getting into a discussion of the hidden matter, the reason for taking the *Hoatzin* on its light-year round-trip. But I couldn't listen to him, because I was no longer alone. The two men next to Jarver had slid quietly across from the other side of the room and were now by my side.

"Captain Roker?" said the blond-haired man. "I wanted to say hello. I hear we're going to be shipmates."

He gazed sincerely into my eyes, took my hand in his big, meaty paw, and held on a few seconds longer than necessary.

"Pleased to meet you," added his companion, leaning across and taking my hand in turn. "I'm Stefan Parmikan. I've heard a lot about you." His smile was a wet, shapeless version of Van Lyle's intimate grin. And instead of riveting me like Lyle, his brown eyes would look anywhere but into mine.

"You heard about me?" I was surprised. McAndrew is closer than a clam. "From whom?"

"The boss. Councillor Griss."

His limp grip was like a lump of wet gristle, much worse than Van Lyle's intimate clutch; but that wasn't what bothered me.

Suddenly, I could put it all together. So far my thinking had managed to get everything wrong. Anna Lisa Griss could push her relatives into high places, and no one would be surprised by that. Nepotism never changes. She had arranged for Dorian Jarver to take over the Penrose Institute.

But it was her bad luck that Jarver happened to be *genuine*, a conscientious scientist with a real feel for physics. She couldn't change his nature. What she *could* do, though, and had done, was to install as his assistants her chosen few: people with no feeling for science, who would follow the councillor's style of operation and do exactly what she said. She had told them to mold the Institute to her own taste, to change it to a copy of the standard Terran bureaucracy that she understood and controlled so well.

And they were doing it. I was now convinced that the real author of the message to me had not been McAn-

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drew. Lyle or Parmikan had structured it, with Anna Griss behind them. Mac had asked for my help, but *she* had been the manipulator. She wanted me on board the *Hoatzin*, for a trip that she would control, through Van Lyle and Stefan Parmikan, from beginning to end.

What made me so sure? There's one point that I neglected to mention about the run-in that we had with Anna Griss out in the Oort Cloud. McAndrew had cut off her arm, which was bad enough but maybe forgivable since he thought he was doing it to save her life. But before that I had stared her down, overridden her authority, and asserted my own position as ship's captain. She had been forced to accept it. But knowing Anna, I knew that would never be forgiven, or forgotten. Not even when she had taken an eye for an eye—or an arm for an arm.

I heard the door at the back of the room open. Jarver was coming back in, and Lyle and Parmikan dutifully hurried back to his side. I shivered, and sat up straight in my seat. Something creepy had brushed by me in the past few minutes, and I didn't yet know what it was.

"So that's it," McAndrew was saying from the podium. "The two best candidates for the missing material needed to flatten the Universe are *hot* dark matter—probably energetic neutrinos with a small rest mass, generated soon after the Big Bang; or maybe *cold* dark matter, particles like the axions needed for charge-parity conservation, or the photinos and other more massive objects required by supersymmetry theories.

"So which should we believe in, the hot or the cold? We don't know. They both have problems describing the way that the galaxies formed.

"Worse than that, we aren't measuring nearly enough of *either* kind of matter. Add everything together, and we still have less than half the mass density needed to make a flat Universe. We must be badly underestimating either the cold dark matter or the hot.

"Which? Theory still can't provide the answer. Most of the events that decide all this began happening in the first 10^{-35} seconds after the origin of the Universe, when we weren't around to do experiments; when even the laws of physics may not have been the same.

"We may never know the composition of the missing matter, until we can put our instruments in the right place for observation—deep in interstellar space."

He halted. Siclaro nodded his appreciation, and Mac came ambling back to his seat.

Naturally, he had missed the whole interaction with Lyle and Parmikan. He'd have missed it even if it had happened under his nose, because he never saw anything when he was talking about physics. He had temporarily forgotten his annoyance at the changes to the Institute, and he seemed quite pleased with life.

I wasn't. I had been brought to the Institute so that McAndrew and I could fly half a light-year from home with Lyle and Parmikan. Anna Griss had engineered my arrival. It was inconceivable that the surprises were all over.

What little goodies were in store when Anna's bully-boys and I were flying far off in the *Hoatzin*?

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I lost track of that question in the busy days before departure. The *Hoatzin* was primed and ready, but I hadn't performed my engine inspection or any of the other preparations that I like to do. I went over the ship, checking everything, and found nothing worse than a slight imbalance in the drive that would have meant a mid-course correction at ship turn-around, a quarter of a light-year from Sol.

Neither Lyle nor Parmikan gave me any trouble. In fact, I hardly saw them until the four of us assembled for final check-in and departure. Then Stefan Parmikan rolled up with about ten times as much baggage as he was allowed.

He objected strongly when I told him to take it away. "All that space." He pointed outside, to the *Hoatzin* with its hundred-meter mass disk and the four-hundred-meter axle sticking out like a great grey spike from its center. "There's oceans of room for my stuff."

How could a man reach adulthood today, and know so little about the McAndrew balanced drive?

"The disk you're pointing at is solid compressed matter," I said. "Density is twelve hundred tons per cubic centimeter, and surface gravity is a hundred and ten gees. If you want to strap your luggage on the outside of that, good luck to you."

"What about the axle? I can see that it's hollow."

"It is. And it has to stay that way, so the living capsule can move up and down it. Otherwise we couldn't balance the gravitational and inertial accelerations. Either we move the capsule in closer to the disk as we increase the acceleration, or you tell me how we're going to survive a hundred gees." When he still didn't show much sign of understanding me, I waved my hand. "The total living accommodation of the *Hoatzin* is that four-meter sphere. I'm not going to spend the next month falling over your stuff. And I'm not going to waste time arguing. That luggage isn't going with us. That's final. Get it out of here, so we can prepare to board."

Parmikan glowered and grumbled, and finally dragged it away. When he reappeared an hour later with a much smaller package, I hustled everyone onto the *Hoatzin* as quickly as possible to avoid any more hold-ups. Maybe I wasn't as thorough as I should have been inspecting luggage. But I suspect it would have done no good if I had been. There must be a definite threat before you start opening people's personal effects. I was anticipating rudeness and arguments and possible discipline problems, but not danger.

Let's call that my second mistake in Project Missing Matter.

Once we were under way I felt a lot better. With the drive on the perimeter of the mass disk turned on, the *Hoatzin* is surrounded by a sheath of highly relativistic plasma. Signals won't penetrate it. Communications with Anna Griss, or anyone else back in the Solar System, were blocked. That suited me fine.

By the end of the first twenty-four hours at full drive we were doing well. We were up to a quarter of light-speed, heading out from Sol at right angles to the plane of the ecliptic and already at the distance of Neptune. We had settled into a typical shipboard routine, each person giving the others as much space

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as possible. You do that when you know you have to spend a long time packed together into a space no bigger than a fair-sized kitchen.

And then, unexpectedly, our communications silence caused trouble.

The *Hoatzin* had been pleasantly quiet for hours. McAndrew had donned a suit, one of the new transparent models so light that you could sit in high vacuum and hardly realize you had a suit on at all.

He was going outside. Most people would be terrified at the prospect of leaving the capsule when the drive is on—if for any reason it turned off, the capsule would automatically spring out to the far end of the axle, to hold the interior field at one gee. But anyone not firmly secured to the capsule would fall at a hundred gee acceleration towards the mass disk. A quick end, and a messy one.

It never occurred to McAndrew that his inventions might fail. He had happily gone outside, for a status check on one of the new mass detectors that he would be using when we reached our destination in the middle of nowhere. We were heading for the region of lowest matter density known, out beyond the limits of the Oort Cloud where we would find less than one atom per hundred cubic meters.

I was looking at the outside display screens, partly to scan the plume of plasma behind the *Hoatzin* for any sign of drive variability, and partly, to tell the truth, because I wanted to keep my eye on McAndrew. He doesn't believe the balanced drive can give trouble, despite the fact that its very first use nearly killed him.

While I had my attention on the screens, Stefan Parmikan crept up behind me. I didn't know he was there until I heard a soft, sibilant voice in my ear. "I am required to send a report to the Council every day, and be able to receive messages from them."

I jerked around. Parmikan's face was only a foot from mine. It was probably not his fault, but why was his mouth always so wet-looking?

"But Professor McAndrew tells me that we cannot send messages to Terra when the drive is turned on," he continued.

"Quite right. To Terra, or anywhere else. The signals can't get through."

"In that case, the drive must be turned off once every shipboard day."

"Forget it." I was a bit brusque, but Lyle and Parmikan seemed to have come along on the expedition without learning a thing about the ship, the drive, or anything else. And Parmikan didn't sound like he was asking—he was telling. "We lose a couple of hours every time we turn power on and off," I went on. "And you'd have the living capsule going up and down the axle like a yo-yo, to balance the change in acceleration from a hundred gee to zero. And anyway, once we're a long way out the signal travel time is so long the messages would be useless."

"But it is technologically feasible to turn off the drive, and to send and receive messages?"

"It is. And practically ridiculous. We won't do it."

Parmikan smiled his wet smile, and for once he appeared to be genuinely pleased about something.

"We will, Ms. Roker. Or rather, you

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will. You will turn the drive off once a day, for communication with Earth."

He drew a yellow document from his pocket, stamped prominently with the Council seal, and handed it to me.

Not Captain Roker. Ms. Roker. It took only a few seconds to scan the paper and understand what it was. I was holding Parmikan's appointment as captain of the *Hoatzin* for this mission. In all the excitement of preparing for our departure I had completely forgotten the original letter to me. An invitation to serve as *crew member* on the expedition, not captain. For the days before our departure I had instinctively and naturally assumed the senior position. And Lyle and Parmikan had been sly enough to go along with me, even addressing me as "Captain Roker" until we were on our way and it was too late to do anything about it.

"Well, Ms. Roker? Do you question the authority assigned by this document?"

"I question its wisdom. But I accept its validity." I scanned down the rest of the page. Parmikan's command extended from the time we left the Penrose Institute until the moment when we docked on our return. No loopholes. "I agree, you're the captain. I don't see anything here defining my duties, though, or saying that I'll agree to them. So if you want to turn the drive off yourself, without my help. . . ."

Stefan Parmikan said nothing, but his sliding brown eyes met mine for one triumphant split-second. He reached into his pocket, pulled out a tiny playback unit, and turned it on.

"I'm reporting for duty right now," said a voice. It was my own.

"For the expedition described in Professor McAndrew's letter to you? But the mission and your role in it are not yet fully defined." That was Dorian Jarver.

"You can define that later. I'm here, and I'm ready to start."

There was a pause, as that section of the recording ended. Then Jarver's voice came again: "In accordance with Captain Jean Pelham Roker's earlier statement, this serves to define her duties on the *Hoatzin* mission identified as *Project Missing Matter*. Ms. Roker will serve as a general crew member, taking her orders and assignments from Captain Stefan Parmikan and from Senior Officer Van Lyle."

Set up. But my own fault completely. I had felt bad vibrations the moment I met Parmikan and Lyle. Then I had gone right ahead and ignored my own instincts. Let's call that my third mistake.

McAndrew was climbing back in through the tiny airlock. I turned to him. "Mac, suppose we turned the drive off every day for a minute or two, long enough to send a burst mode message back to Earth. Allowing for the time we need to power the drive down and back up, how much would that add to our total trip?"

He stared at me for a moment, then his jaw dropped and his face took on a strange half-witted vacancy. That was fine. It just meant that he was off in his own world, thinking and calculating. I had given up trying to understand what went on inside McAndrew's head when he was solving a problem. Even though what I had asked him was straightforward, and I could have done the calcula-

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tion myself given a little time, I would bet money that he was not using any technique I'd have chosen. As one of the Institute members told me years ago, McAndrew has a mind that sees round corners.

"Five days," he said after a few seconds. "Of course, that's *shipboard* days. Two months Terran, allowing for time squeeze."

"Quite acceptable," said Parmikan. "Ms. Roker, please work out the necessary arrangements and bring them to me."

He turned and headed off for the private area of his own bunk, leaving me to fume and curse. And then, after a few minutes, to sit down and work out the best times for a regular interruption to the drive. I had to work it into other activities, so that Parmikan would make his daily call with minimum disruption to ship routine.

McAndrew came to me when I was almost finished. "Jeanie, I didn't catch on to what he wanted when you asked me that, or I'd have said it was hard to do. You don't have to take this sort of guff from him."

"I do." I picked up the results of my efforts, aware that Van Lyle had been watching me all the time I was working. "You know the first rule of space travel as well as I do: Like it or not, you can only have one captain. Parmikan is the captain of the *Hoatzin*."

I carried the schedule I had generated across to Parmikan's curtained rest area. The little private spaces allotted to each of us were intentionally set as far apart from each other as possible, around the perimeter of the living capsule. I rapped on the curtain rail. "This is my recommended schedule," I said, when Parmikan's head poked through. I held it out to him, but he did not take it.

"Is it a simple procedure?" he asked.

"I believe so. I've done my best to make it as simple as possible."

"Good. Then you should have no trouble carrying it out. Notify me when the drive is off, and we are ready for our first communication opportunity with Terra. By then I'll have another assignment for you."

His head vanished back through the curtain. I had an insight into Parmikan's style of command. He would give all the orders. I would do all the work. This was Anna Lisa Griss' revenge for my asserting authority over her. I would have to obey Parmikan's every random whim for two months.

I was still naive enough to think that would be enough to satisfy her. My fourth mistake, was that? I'm beginning to lose count.

I stayed angry at being ordered around, until I remembered Lyle and Parmikan's general ignorance of shipboard matters. Then I thought, Hey, it's better like this. How would you feel if Parmikan took over the controls *himself?* And I went away to set up the program to power down the drive at regular intervals.

Except that McAndrew had heard my exchange with Parmikan, and he was feeling sorry for me. He insisted that he would do the tedious job of changing the drive program schedule. I let him. It was quite safe to do so, because Mac's such a perfectionist on this sort of thing that he sometimes makes me feel sloppy.

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But Mac is only devious in scientific matters. He didn't catch something in the *Hoatzin*'s overall mission profile that I would have noticed at once.

I discovered it much later, and almost too late. Call that my fifth mistake, and let's stop counting.

To me, the interruptions to our outward progress were a useless nuisance. I have no idea what was sent or received by Parmikan and Lyle in their daily communications. I was specifically excluded from them, and in any case Parmikan had me far too busy with a hundred other things to worry much about messages—he had an absolute genius for thinking up demeaning and pointless tasks. I do know, though, that the person sending or receiving at the other end was not Dorian Jarver. The link was set up to a location on Terra, not to the Penrose Institute.

And McAndrew, being McAndrew, contrived to turn the periods when the drive was off into an opportunity. He decided that he could use those few dead minutes every day to perform his first experiments. One morning right after breakfast I went to the rear of the living capsule to escape from Van Lyle—he, and his probing eyes, followed me everywhere. I found McAndrew sitting beside his instrument panel, frowning at the wall.

"Problems?"

He shrugged, and scratched at the back of his balding head. "I'd have said no. Everything passes the internal checks. But look at this." He pulled up a display. "I've got the most sensitive mass detectors ever, lined up on our final destination. All the other instruments confirm that there's absolutely nothing out there. But see these."

He pointed to small blips in the output level of the instruments.

"Noise?" I suggested. "Or the result of our high velocity? Or maybe a local effect, something on the *Hoatzin*?" He had told me that his new instruments were supernaturally sensitive to disturbance.

"No, they're definitely external, and far off. And *regular*. That's just the signals I'd be getting if massive objects were flying, evenly spaced, across my field of view. Except there's nothing there. It's a total mystery."

"Then you'll just have to be patient. We're already past turn-around. In twelve days we'll be there, and you'll be able to see for your—"

"Crewman Roker!" It was Parmikan's voice, ringing through the living capsule. "Come here immediately. I have a task that must be performed at once."

I took a deep breath, and held it. Another fun-filled day was beginning. Twelve more to go, before we came to rest in the most perfect nothingness known to humans, half a light-year from the Sun.

With the whole habitable space of the *Hoatzin* only four meters across, I knew before we left the Institute that we'd be living close. But given the lack of privacy, there was one form of closeness I had never expected.

The surprise came late in the evening on the twenty-third day out, when Mac was in the shielded rear of the living capsule muttering over his still-anomalous instrument readings. The blips were growing. With Parmikan's con-

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sent Mac had gradually changed our course, angling the ship's direction of travel towards the strongest source of signal. We would arrive a tenth of a light-year away from our original destination, but as McAndrew pointed out, the choice of that had been more or less arbitrary. Any place where the matter density was unusually low would serve his purpose equally well.

By eleven o'clock Stefan Parmikan was asleep. I was sitting cross-legged on my bunk, listening to an Institute lecture from my talking library. It was "Modern Physics for Engineers," by Gowers, Siclaro, and McAndrew; a course designed to be less high-powered than the straight two-hundred-proof Institute seminar presentations. There were three other series available, of rapidly descending levels of difficulty. They each had official names, but inside the Institute they were known as "Physics for Animals," "Physics for Vegetables," and "Physics for Football Players."

I had brought all four, just in case, but I was holding my own with "Physics for Engineers." I was finally gaining a clearer idea of just why we had to charge off half a light-year from Sol.

Something was absent from the Universe, something that the best brains around thought had to be there: Missing matter.

The "bright stuff"—visible matter—isn't nearly enough to make the Universe hover on the fine line between expanding forever, and collapsing back one day to the Big Crunch. That's what the theorists want, but there's only about 1 percent of the mass needed in the bright stuff. You can pick up a factor of ten or so from matter that's pretty much the same as visible matter, but happens to be too cold to see, and that's all.

This leaves you about a factor of ten short on mass. And there you stick. You have to start laying bets on other, less familiar materials.

Neutrinos moving up close to the speed of light—Hot Dark Matter—are one candidate. There are scads of neutrinos around, generated soon after the Big Bang but damnably difficult to find by experiment. Neutrinos don't interact much with ordinary matter. They'd slip through light-years of solid lead, if you happened to *have* light-years of lead available. They're a candidate for the missing matter, but they're not the front runner. They don't give a Universe with the right lumpy structure, and anyway they come up short on total mass.

The other candidates are much slower and heavier than neutrinos. They're the Cold Dark Matter school, axions and photinos and gravitinos, and *they* don't give the right lumpiness to the Universe, either. Even adding them to the neutrino mass, the whole thing still came up too small. McAndrew was saying, in effect, we've gone as far as theories can go. Let's get out there, where the experiments have a chance to succeed, and *measure* how much Hot Dark Matter and Cold Dark Matter is around. Then we'll know where we stand.

It was all fairly new to me. I was concentrating deeply, struggling with the theories of WIMPs, Weakly Interacting Massive Particles, when I was interrupted.

For the past three days I had been aware of Van Lyle hanging around me.

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I became a lot more aware of him when two arms suddenly went around me from behind, and two hands clasped my breasts.

"Hey, Jeanie," Lyle's voice whispered in my ear. "You've got lovely tits. It's going to be nice and quiet for a while. Want to get friendly?"

I jerked forward along the bunk, untangling my legs and trying to pull myself free. He was hanging on tight. That *hurt*.

"Get your damned hands off me." I wanted to say something a lot worse, but I knew we were going to be cooped up in the same space for another few weeks, no matter what. I had been trained to avoid onboard confrontations, and I wanted to stay cool and end this politely.

I swung around to face him and pushed myself away.

"Oh, don't be like that." He was grinning, a big, smarmy God's-gift-to-women grin. "Come on. Lighten up. We could have some real fun."

He reached out towards my breast again, and I pushed his hand away. "Quit that, Lyle! I tell you, I'm not having any."

"You haven't tried it. Lots of women could tell you, you won't be disappointed. Want to have a look at my testimonials?" And then, as I pushed his groping hand away again, this time when it reached towards my crotch, "Hey, Jeanie, you're *strong*. I just love strong women."

"You do, do you?" I'd had it. "*This* strong enough for you?"

I swung with all my body behind it as his face came forward, and got him with my fist right on the bridge of his nose.

It hurt like hell—hurt *me*, I mean. I didn't care how much it hurt him. But I don't think he enjoyed it, because as the blood spurted out of his flattened nose and splashed all over my bunk, he let out a terrible howl that brought McAndrew running.

Just as well, because by that time I was upright, off my bunk, and all set to kick Lyle in the balls at least ten times as hard as I'd punched his nose. McAndrew got in the way before I could do it. He leaned close to Van Lyle, a rag in his hand to mop up blood.

"What happened?"

Lyle produced only a horrible snorting noise.

"Tripped as he was coming in here," I said, "and banged his face on the edge of the bunk. Get the medical kit."

McAndrew glanced at the bunk as Stefan Parmikan finally appeared. I knew that Mac was doing an instant height and angle match, and rejecting it. But he never said a thing. Nor did Lyle, unless you count the groans when Parmikan was moving his broken nose around in an attempt to achieve a reasonably straight result.

We fixed the nose, more or less, and sedated Lyle. Parmikan went back to bed. During the sleep period, McAndrew leaned over the edge of my bunk and whispered to me. "Jeanie? I know you're awake. Are you all right?"

"I'm just fine." I didn't want him as furious as I was.

"He didn't bang himself on the bunk, did he? He made advances to you, and you hit him."

"What makes you think that?" Mac's insights were supposed to be into

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nature, but not human nature.

"He was talking about you two days ago, when you weren't present. He said he wanted to take you to bed. Get a piece, he said."

"And you were *there?* Why for God's sake didn't you stop him? Tell him that you and I are lovers, have been for years."

There was a long, worried pause. "It wouldn't have been right, talking about you like that. And Jeanie, I don't *own* you, you know."

McAndrew, McAndrew. If I weren't so fond of you, I'd wring your scrupulous Puritan neck.

"But you know what?" he went on, "I'm afraid that it's going to make for a more difficult working atmosphere during the experiments."

It's a good thing it was dark, so I couldn't take a shot at *his* nose, too.

The first twenty-three days of the trip out had seemed pretty bad. I learned the next morning that the remaining five were going to be a lot worse—and then after that we had the period of McAndrew's experiments to look forward to, followed by a four-week return journey to the Institute.

The pattern was established on the twenty-fourth day. Van Lyle was back on his feet early. The bruise from his broken nose had mysteriously spread, to give him two purple-black eyes. With a white, rigid plaster across the middle of his face, he resembled a vengeful owl as he staggered out of his bunk. He glared around him.

"The inside of this capsule is dirty. It must be cleaned."

"It's not bad," I said. "It's just the way you'd expect the ship to look after three weeks."

"I'll be the judge of that." Lyle picked up a dish of soggy cereal, inverted it, and deliberately dropped it to the floor. "Get to work. This cabin first, then my quarters. I'll be back to inspect your progress this afternoon."

I held myself in—just. When Stefan Parmikan appeared ten minutes later, I had all the cleaning equipment out of the ceiling racks and ready for use.

He looked, not at me but past me. "What do you think you are doing?"

"Getting ready to clean the cabin. Following Officer Lyle's instruction."

"Very well. You can do that later. I need you to explain the procedure for ship automatic course tracking to me."

Unbelievable. Could it be that Stefan Parmikan was at last taking an interest in the way that the *Hoatzin* worked? I rose to follow him, but he turned and pointed to the cleaning equipment.

"Put those away first, back in the ceiling racks. I'm not going to spend the whole day falling over your stuff. And I'm not going to waste time arguing. You can get everything out again later."

It didn't help to recognize that Parmikan was quoting my own words, about the luggage of his that I had refused to allow aboard.

I began to put away the cleaning equipment, and thought favorably of Fletcher Christian.

No one on the *Hoatzin* seemed happy for the next five days. Parmikan and Lyle constantly tried to push me over the edge, and were constantly disappointed. They came close, but I cer-

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tainly wasn't going to give them the pleasure of knowing *how* close.

And McAndrew, who should have been as happy as a pig because the time of his experiments had arrived, had become intense and introverted. The *Hoatzin* had homed in close to his strongest anomalous signal, but it did not seem to have resolved his problem.

"Look at this, Jeanie," he said, during one of my rare breaks from slavery. I had just checked that the ship had achieved its final location and velocity, and confirmed that we were at rest again relative to Sol. "These are *real-time* signals, happening right this minute. I've got instruments focused on a region only two light-seconds from here. You can see the visual display of it on the left half of the screen."

I looked. Other than a triangle of three bright reference stars, the visible wavelength display was blank.

"Nothing there," I said.

"Quite right. And now, the input from the mass detectors. They're set up to scan the same field, and I've got them in imaging mode focused for two light-seconds away." McAndrew popped the mass detector result on the right, as a split-screen display.

I stared. I expected to see nothing on the right side of the screen, either, and that's exactly what I saw. The region two light-seconds from us, where McAndrew's mass detection instruments were focused, was empty of matter—more empty, in fact, than any other known region.

"Well," I began to say. And then something impossible happened. The left-hand screen at visible wavelengths continued to show nothing but distant reference stars; but the screen displaying the mass imaging system inputs showed an object floating steadily across it, from top to bottom. The blob was clean-edged and irregular in shape, its outline like a fat, curved and pimpled cigar. It took maybe ten seconds from the first appearance on the top of the screen to its leisurely disappearance from the lower boundary. It must be moving at just a few miles a second relative to the *Hoatzin*.

"Mac, you've got the displays set up wrong. Those have to be showing different fields of view."

"They're not, Jeanie. I've checked a dozen times. They're showing the same part of the sky."

"Rerun it. Let me see it again."

"I don't need to. Wait twenty seconds, and you'll see another one. About one a minute."

We waited. At last a second shape, apparently identical to the first, came floating across the mass detector screen. And again the visible wavelength screen remained blank.

"Ultraviolet," I said. "Or infrared, or microwave . . ."

"I've checked them all. Nothing, from radiation or particle sensors. Only the signal from the mass detectors."

"So they're *black holes*. Kernels. They have to be."

"That's exactly what I thought, when we were a ways off and the signal was just a fuzzy blob with no structure. But just you look at the shape of that"—a third shape like a thick, warty banana was crossing the screen—"when you know as well as I do that any black hole has to have at least rotational symmetry. Those things have no axis of symmetry

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at all. And another thing. I did an *active* test. I sent a particle stream off to intercept one of those objects. If it were a black hole, you'd get a return radiation signal as the particles were gravitationally caught. But I got *nothing*. The particles went right on through as though there wasn't anything there at all."

I had a strange, prickly feeling up the back of my neck. We were observing nothing, a vacuum specter, a lost memory of matter. *By a knight of ghosts and shadows, I summoned am to tourney, ten leagues beyond the wide world's end. . . .* Except that in our case, ten leagues had grown to half a light-year.

"Mac, they're *impossible*. They can't exist."

"They do, though." McAndrew's eyes were gleaming. I realized that I had mistaken his emotion. It wasn't frustration. It was immense pent-up excitement and secret delight. "And now I've seen them in more detail, I know what they are."

"What, then?"

"I'll tell you—but not until we get a chance for a real close-up look. Come on, Jeanie."

He headed straight for Parmikan's private quarters, banged on the wall, and pulled the curtain to one side without waiting for an invitation. Parmikan and Lyle were both inside, heads close together. They had kept to themselves completely since the previous day, after an unusually long message to or from Earth. They jerked apart as McAndrew barged through.

"We want to move the *Hoatzin* a bit," he said without preamble. "And I have to go outside. I'd like Captain Roker to go with me."

If he was asking permission, calling me "Captain Roker" to Stefan Parmikan was the worst way to go about getting it. I expected an instant refusal. Instead a rapid glance passed between the two men, then Parmikan turned to McAndrew.

"What do you mean, move the ship?"

"Just a smidgeon, a couple of light-seconds. There's something I need to look at as part of my experiments. As soon as we're in the right position I need to take a couple of mass detectors outside with me and examine a structure. It will take a few hours, that's all. But it's a two-person job, and I'll need help."

I certainly didn't expect that Lyle or Parmikan would volunteer for the job of helper, but equally I didn't expect that they'd agree to my doing it—if I were outside, how could they give me disgusting chores? But Parmikan nodded his head at once.

"Right," said McAndrew. His diffident manner had vanished. "Jeanie, while I get the equipment ready I want you to take the *Hoatzin* to encounter one of the anomalies. Put us smack in the middle, and set us to hold at zero relative velocity."

I didn't argue. But as he went off to the rear of the living capsule, I did exactly half of what he had requested. A small, watchful region of my brain was awakening, from a slumber it must have been in ever since I decided to reply to McAndrew's letter by flying straight to the Institute. Now I closed in on one of the objects and set us to zero relative velocity—but I kept our ship a couple of kilometers clear rather than providing

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McAndrew's requested encounter. He might know exactly what he was dealing with, and be sure that it was safe. Until I had that knowledge, too, I was going to regard any region of empty space occupied by a mystery as possibly dangerous.

As I was completing my task I noticed a minor oddity in the operations of the *Hoatzin*'s computer. The program was functioning flawlessly, but as I directed each change in position or speed, a status light indicated that an extra data storage was being performed. The response time was a fraction of a second longer than usual.

I'd probably have caught it when at Parmikan's insistence we switched the drive on and off every day, but Mac had programmed all those changes as a favor to me. And if McAndrew had been ready to go outside at once, I might have ignored it now. Instead, I took a look to see where the generated data were being stored.

I found a Dummy's Delight.

The data I was creating were being placed in a trajectory control program of a type much despised by professionals. It was the sort of thing that anyone could use and no one ever did, because it was guaranteed to be inefficient. In a Dummy's Delight, for every move made by the ship the inverse move was generated and stored. If the program were then executed, the ship would return to its point of origin along whatever convoluted trajectory it may have taken to fly out.

The program's only advantage was simplicity. One push of a button, and all need for piloting went away.

But there was no way that *we* would fly back along our original trajectory—there were much more efficient thrust patterns. And I certainly hadn't given the command to place the required data into the Dummy's Delight before the *Hoatzin* left the Penrose Institute.

Had Mac done it? And if so, why?

My wariness node had started to work overtime. On impulse I wiped from memory the whole Dummy's Delight sequence, and left a message on the control screen: AUTOMATIC RETURN PROGRAM TO TERRA HAS BEEN ERASED BY CAPTAIN ROKER. It seemed reasonable when I did it, but I started to have second thoughts as I hurried to join McAndrew. He had his mass detector survey instruments working as free-standing units and was already in his suit.

"Mac." I waited until I had my own suit on, and was absolutely sure that we could not be overheard by Van Lyle or Stefan Parmikan. "Did you set up a Dummy's Delight in the *Hoatzin*'s computer?"

He was busy, guiding the bulky detectors into the lock. "Now why would I do a daft thing like that?" he said, and vanished into the lock himself.

Why *would* he do a thing like that? I asked myself. Why would *anyone* do it?—unless they suspected that no competent pilot, like me or McAndrew, would be around to fly the *Hoatzin* on its return journey to Sol.

Paranoid? You bet. It's the only way to fly.

I emerged from the lock into that great forever silence that fills all the space between the stars. Sol was dwin-

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dled, indistinguishable from dozens of others. I picked it out from its position, not its superior brightness. The region I floated in appeared totally empty and featureless, despite the suit's vision enhancement systems. Particles were fewer here, the vacuum a little harder. But the human observer would never know the difference.

I glanced back at Sol. Look at the situation any way you liked; if I blew it and something went wrong, it was a long walk home.

I propelled myself gently away from the ship and towards McAndrew. He was staring at his mass detector readings in great irritation.

"Jeanie, you've made a mistake. We're kilometers away from the source."

"We certainly are. Two kilometers, to be exact. I know you can see right through it and it looks like nothing's there, but I want to approach this particular nothing very carefully."

He gave the patient sigh of a long-suffering martyr. "Ah, Jeanie. There's no *danger* here, the way you're thinking. I know just what this is."

"Maybe. But you haven't told me."

"I will, though, right now. It's *shadow matter*." And then, seeing my stare, "I'm surprised you've not heard of it."

"I know, Mac. I'm a constant disappointment to you. But I haven't. So tell me."

"It's wonderful. Right out of supersymmetry theory. Soon after the Big Bang—about 10^{-43} seconds after it, actually, before anything else we know about happened—*gravity* decoupled from everything else. Sort of like the way that radiation decoupled from matter, but the gravity decoupling happened much earlier. So then you had a symmetry breaking, a sort of splitting, and two types of matter were created: ordinary matter and shadow matter. Just like matter and anti-matter—except that matter and shadow matter can't interact by strong nuclear forces, or radiation, or the weak nuclear force. They can *only* interact by gravitational influence. You'd never detect shadow matter by firing particles at it. We proved that for ourselves. The particles feel the gravitational force, but that's tens of orders of magnitude too weak to do anything noticeable."

I stared at nothing, in the direction that the mass detectors were pointing. "You're saying that whatever is out there is as real as we are—but we can't see it?"

"Can't see it, never will be able to see it. Seeing depends on interaction with radiation. The only way to learn what we've found is through these." He pointed at the mass detectors. "We're safe enough, as I said. But we have to do some detailed mapping. Who knows what that is out there? It could be a shadow matter star—we don't have any idea how big a star might be in that universe, or what the laws of force are. Or maybe we're detecting a set of interstellar shadow matter spaceships, or a column of shadow matter ants marching in a shadow matter superworld.

"You think I'm joking, but I'm not. It could be anything. The only way we'll get any idea of what we've found is by plotting structure. That's why I need you—it's a two-person job, to make transects."

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We're safe enough, he had said. But maybe only while we were outside the *Hoatzin*.

"Mac, before we start your work we've got to talk. I think we have a bad problem." I told him about the Dummy's Delight on the ship's computer.

He frowned through his suit visor. "But why would they waste data storage on a thing like that?"

"So they could get home, even if something happened to both of us." I took the last mental step, the one I had been resisting. "Mac, we're not intended to return from this trip. The plan is for us to vanish while we're out here. If the drive of the ship were turned on now, who'd ever know what had happened to us?"

He turned to stare at the *Hoatzin*. "They wouldn't *dare*."

"Not now they wouldn't. I wiped the program they were relying on to fly them back. So they need us." *Or one of us*. But I didn't say that. "We're safe enough for the moment."

"But what about when we go back inside? We can't stay out here forever."

"I don't have an answer for you. We've got enough air for six or seven hours. We have to think of something—soon."

We *had* to think of something. But we didn't succeed. My mind stayed blank. McAndrew is a superbrain, but not when it comes to this sort of problem. After half an hour floating free not far from the ship, he shook his head.

"It's got me beat. But this is silly. There's no point in sitting here doing nothing. We might as well get on with the measurements."

He placed one mass detector in my care, with its inertial position sensor tuned to the *Hoatzin* as reference, and started to steer me under his direction from one fixed place to another, while he moved himself in constant relative motion. He apparently knew exactly what he wanted. That was just as well. My own thoughts were all on the situation aboard the ship. What would we do when our air ran low?

I worried that problem with no result while McAndrew made four straight-line passages, right through the middle of the kilometer-wide region that he described as shadow matter. The mass detectors confirmed that something was there. I saw absolutely nothing.

On the fifth passage through, McAndrew paused halfway. He called to me to move closer, while he carried his own detector through a complicated spiral in space. At the end of it he left his mass detector where it was, flew across to me, and examined the recording on my instrument.

"Well, I'm damned," he said. "Jeanie, I think you were right. Stay there." And leaving me mystified and feeling about as intelligent as a marker post, he flew away. This time he moved his mass detector through an even more complex path in space, pausing often and proceeding very cautiously.

"I've still no idea what this is, overall," he said when he came back. "But I'll tell you one thing for sure. There are structures in shadow space that I've never met in our spacetime."

"Right about *what?*" I asked. "You just said I was right. But what was I right about?"

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"That we ought not to set the ship in the middle of that, without knowing more about it. I'm seeing evidence of gravitational line singularities, or something very like them, running across the shadow matter region. You don't find those in our Universe. If we had flown in too close to one of them, we might have found ourselves in trouble."

"You mean we're not in trouble *now?* With Lyle and Parmikan waiting for us."

"I've been thinking about that, too." He came close, and his face was earnest and unshaven within his visor. "I think you're overreacting. There's no evidence at all that Lyle and Parmikan even knew there was a Dummy's Delight set up in the *Hoatzin*'s computer. And certainly there's no evidence they mean us any harm. But *anyway*," he went on, before I could interrupt, "one thing's for sure: When we go back in the lock, I should enter first while you stay outside. I know both of them, they respect me, and they'll not do anything to hurt me."

McAndrew is a pathetically bad liar. I didn't argue with him. But when we were a few meters from the lock I said, "You've got it backwards. *I'm* the one they won't hurt, because they need a pilot to get home. And you don't know how to work our only weapon. Don't stand too near the hatch of the lock."

I dived for the airlock, pulled myself inside, and swung it closed in one movement, leaving Mac to bang on the outside. While the lock was filling with air I did a little work of my own. It required that three separate safety procedures be overridden, so it took a few minutes. At last I moved forward to open the inner lock door, then jumped back at once to stand by the outer one.

I didn't know what I was expecting. Lyle and Parmikan, going about the normal business of the ship, with a stack of messy chores ready for me? Or waiting to complain that I had for no reason at all wiped out a program that one of them had set up in the computer, for a wholly innocent purpose?

What I hadn't expected was a projectile weapon, held in Van Lyle's hand and pointed right at my belly button. I rammed my left fist down on the lock control, as the thought flashed through my head that there should have been a more thorough luggage inspection when we boarded the *Hoatzin*.

I moved as fast as I could, but they had been ready and waiting. I was too slow. Lyle pressed the trigger.

As he did so two things happened. Parmikan smacked at Lyle's hand and screamed, "Don't kill her! We need her to get us back." That saved me, spoiling Lyle's aim. In the same moment the outer lock door, its final safety trigger broken by the force of my fist, blew outward in a rush of air.

I flew out with it, knowing that my last-ditch plan to fight back had failed. I was hit. And my secret weapon was useless, because Lyle and Parmikan were already wearing suits.

I felt the fainting weakness that comes with a sudden drop of blood pressure. Then my suit resealed, and a few seconds later McAndrew was grabbing at me to halt my spin. He had followed me as I emerged in that crystal cloud of cooling air.

I felt pain for the first time, and looked down. Half the calf of my left

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leg was missing. The automatic tourniquet had cut in and tightened below the knee. The flow of blood from the wound had already stopped. I would live—if we somehow survived the next few minutes.

Which didn't seem likely. Lyle and Parmikan had emerged from the lock, and Lyle still had his gun. He raised it. And shot me again.

Or he would have, had he been the least bit familiar with free-fall kinematics and momentum conservation. Instead the recoil of his gun sent him rolling into a backward somersault, while the bolt itself flew who knows where.

Before Lyle could sort himself out and fire again, McAndrew was dragging me away, using his suit propulsion system at maximum setting to carry both of us along. One nice thing about Mac, he didn't need much data to form a conclusion.

"Don't try a long shot." That was Parmikan to Lyle, over the suit radio. "She's injured. Get in close. Then we finish him and grab her. But *don't kill her*—she's taking us home."

"I won't kill her." That was Lyle, the white plaster on his nose vivid through the suit's visor. "Not 'til I'm done with the bitch. She'll wish she was dead before that."

They were coming after us, knowing that we had no place to hide. It was our misfortune to find ourselves, weaponless and pursued, in the emptiest quarter of known space. Nowhere to run to, and soon we would be out of air.

McAndrew was retreating anyway, dragging me along with him, but not in a simple, straight-line run. We were zigzagging up and across and sideways, rolling all over the sky; which made good sense if you were trying to evade being shot, and no sense at all when your enemy had just declared that he would not shoot until he got close.

Then we stopped dead. Mac glanced all around him, sighting for Parmikan and Lyle, the two mass detectors just where we had left them, and the shape of the *Hoatzin*, farther off. He lifted us a few meters upward, and halted again.

"Here we are, then," he muttered. "And here we stay."

Lyle and Parmikan hadn't moved while Mac and I had been corkscrewing our way around in space. Now they started towards us. Soon I could see their faces, white in the reflected glow of the visors' built-in instruments.

Still McAndrew didn't move. The feeling of distance and unreality that had swamped me the moment I was shot started to fade. At last I was scared. But when I started my propulsion system, ready to take off again away from the advancing men, Mac held out his hand to stop me.

"No, Jeanie. Hold by, and don't move."

They were closing on us. Parmikan was two or three meters in the lead. Lyle still held the gun, but he had learned his lesson. He would not fire again until he was at point-blank range, too close to be thrown off in his aim by the effects of free-fall rotation.

"Mac!" We couldn't stand still and be slaughtered like sheep. I swung to argue with him, and saw the expression on his face. He was agonized and biting his lower lip. "Mac, come on. We can't just give in."

But he was shaking his head at me.

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"I'm sorry, Jeanie," he said. "This isn't me. I can't go through with it. No matter what happens next, I have to give them a chance." And he lifted his arm towards Lyle and Parmikan. "Don't come any closer. Stay right there. You are in terrible danger."

That stopped them—for a second or two. They stared all around, and saw nothing. Lyle snorted through his broken nose, while Parmikan laughed aloud for the first time since I had met him.

"Don't try that on us, McAndrew," he said. "We weren't born yesterday. If you stand still, I promise you'll get yours clean and quick."

He was moving forward again. My suit's vision enhancement showed the grin on his shapeless mouth. He looked as happy as I had ever seen him. And then the clean white of his suit was broken by a thin black line that ran across Stefan Parmikan from hip to hip, about two inches below his navel.

He stared down at himself as the line widened. He started to scream, and tried to back up.

It was too late. His motion carried him forward. As it did so he *shrank*, shortening and squeezing in towards his hips. The thin black line became a rolling tunnel of red and purple across his whole body. Twisted internal organs were moving into it from above and below. Then Parmikan had passed all the way through.

The scream ended. A pair of legs, still held together at the top, came floating on towards us. Separate from it moved a torso, cleanly severed. Blood gushed out and froze as a fine icy spray.

Lyle, a few meters behind, had enough time to stop. He paused, still holding the gun.

"Hand that over." I summoned what little energy I had and spoke over the suit radio before McAndrew had time to react. And then, when Lyle hesitated, I said, "Hand it over *right now*. Or get just the same as he did."

He hardly seemed to be listening. His eyes were following the horror of Parmikan's severed body. But he nodded and released the gun, which floated gently away from him.

It's a measure of how far gone I was that I actually started out towards it, until McAndrew grabbed me.

"You stay where you are, too," he said. "And Lyle, don't move a millimeter until we come around and get you. There's other gravitational line singularities through this whole volume."

We began to move again, McAndrew hauling me along like ballast in a strange helical path that wound its way towards Van Lyle. Finally McAndrew was able to reach out and snag the gun.

"All right." He waved it at Lyle, then towards the *Hoatzin*. "We've got a clear run from here to the ship. You start that way. And remember that I understand free-fall ballistics a lot better than you do. I won't miss."

The three of us drifted slowly back to the lock, but McAndrew would not let Van Lyle enter. He handed me the gun. "You first, Jeanie. Can you fix the lock so it works?"

"I think so." I moved inside. "I just have to reset the safety interlocks."

I made it sound trivial, and it should have been. But I kept half blacking-out before I was done and able at last to refill the interior of the *Hoatzin* with air.

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It seemed forever before the lock cycled again. I wondered and stayed tense. I had the gun. Suppose Lyle had taken advantage of that and overpowered McAndrew?

I dropped those worries when Lyle emerged from the inner lock. His manner and bearing were of a crushed man with no fight left in him. I made him take his suit off, but I kept my own on until McAndrew finally came through the lock.

He didn't give Lyle a look. He came straight across to me and examined my injured leg.

"I'm sorry, Jeanie," he said, as he helped me ease out of my suit. "I know I put us in danger, warning them the way I did. If Parmikan had stopped in time we might have been killed. But I couldn't let them go on moving into that line singularity, without giving them at least a chance to stop. I just couldn't do that. You'd have done the same thing, wouldn't you?"

"Of course I would."

Like hell. If it had been up to me, Lyle would be floating around in two halves, the same as Stefan Parmikan. But then, compared with McAndrew I'm a barbaric, vengeful throwback. "Don't worry about it, Mac. What you did was the right thing."

I winced, as the suit came free from my calf and caught on crusted blood. "So whose idea was it, Van Lyle?" I said. "Who decided that on this expedition, McAndrew and I wouldn't be going back?"

He had been sitting slumped over, staring at the floor. He looked up, opened his mouth to speak, then changed his mind. He shook his head.

I didn't blame him. When we arrived home he would be charged and surely convicted; but nothing the system authorities could do to him was half as bad as Anna Lisa Griss' vengeance if he betrayed her.

McAndrew had gone across to the capsule's medical center and was returning with two spray syringes. "I'm going to put you under, Jeanie, while I dress your leg," he said. "You'll have to wait until we're home for a full repair. But first, to be safe . . ."

He went to Van Lyle and pressed the loaded syringe against the back of the stooped man's neck. Lyle tried to stand up, with a startled expression on his face. It was already too late.

"Better if we keep him under all the way back," Mac said, as after a few struggling seconds Lyle slid forward and fell face down on the floor. "That way we don't have to worry."

I wasn't worrying. I was going to be next, and physically I was ready for it. My calf was beginning to throb mercilessly. Still I held up my hand in protest. "Mac, wait a minute. We shouldn't head back until you've finished your experiments. And you've hardly started."

He moved behind me. "Don't be daft, Jeanie. I can come here any time. And I surely will. There's big questions to be answered. I need to map the structure of those shadow matter objects in more detail. And now we've got another candidate for the hidden matter. How much is cold dark matter, how much hot dark matter, how much *shadow* matter?"

The cool nozzle of the syringe touched the back of my neck, and the spray diffused through my skin. I felt

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the effect at once as a pleasant relaxing warmth that spread through my whole body.

"Mac," I said, as the capsule of the *Hoatzin* began to blur around me. "You saved us, but I don't know how you did it. How did you know where to go, to put that gravity singularity right between us and those two?"

"Easy enough," he said. "I had the measurements from the mass detectors. That made it a standard problem of inverse potential theory: Given the field, where are the masses needed to generate it? I already felt sure that there were line singularities of shadow matter, ones that would work—gravitationally—on anything in our Universe that encountered them. But just where were they? I worked that out while you were inside the lock, playing your fun and games with Lyle and Parmikan. Of course, I had to make simplifying assumptions and hope they wouldn't affect the answer. And it would have been really nice to have a computer. But there was no time for that. I did what I could."

I did what I could. What he had done, in the few minutes before I was blown out of the lock in a gust of freezing air, was to solve, mentally, a problem that would have taken me half a day to set up, and a computer to find an answer. And he had done it knowing that the next half hour might end his own life.

Cold Dark Matter. Hot Dark Matter. Shadow Matter. The words spun through my mind as the world darkened, and McAndrew's earnest face faded before my eyes. *Cold Dark Matter. Hot Dark Matter. Shadow Matter.*

Which one had dominated our past, to create the present structure of the Universe?

I had no idea. All I knew for sure, as I slid into unconsciousness, was that the *future* of our Universe was going to be dominated by *cool grey matter*; the sort that McAndrew and a few rare others like him have hidden between their ears. ■

● Nickel may be alloyed with most of the other metals, but the compositions have no particularly interesting properties.

William Henry, "The Elements of Experimental Chemistry," Philadelphia, 1819.

Submitted by G. Harry Stine

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the reference library

By Tom Easton

The Waste Lands, Stephen King, Plume (NAL/Dutton), $15.00, 512 pp. (ISBN: 0-452-26740-4).
Martian Rainbow, Robert L. Forward, Ballantine/Del Rey, $18.00, 335 pp. (ISBN: 0-345-34712-9).
Far-Seer, Robert J. Sawyer, Ace, $4.50, 304 pp. (ISBN: not specified).
Starseed, Spider and Jeanne Robinson, Ace, $17.95, 248 pp. (ISBN: 0-441-78357-0).
Lair of the Cyclops, Allen L. Wold, Warner, $?, 282 pp. (ISBN: not specified).
Captain Jack Zodiac, Michael Kandel, Broken Mirrors Press (Box 473, Cambridge, MA 02238), $13.95, 220 pp. (ISBN: 0-9623824-6-9).
Griffin's Egg, Michael Swanwick, St. Martin's, $15.95, 101 pp. (ISBN: 0-312-06989-8).

Stephen King's *The Dark Tower* series began with *The Gunslinger*, which told of a world that might be some distant future Earth, where the upholders of civilization were the gunslingers. It was a world solidly rooted in the American myth of B-movie westerns, and a world threatened by new values, by magicians and deceivers and wars. Into it was born Roland, to be trained in the arts of the six-gun, later to be cast out by betrayal and destruction. The last remnant of the gunslinger culture, the last of the gunslingers, he set out across the desert in search of the man who had brought his past down in ruins and in quest of the enigmatic Dark Tower. Along the way he found a boy of our world, Jake, who had been pushed into New York traffic; upon his death, he appeared in Roland's world. Later faced with the choice between himself and the boy, he let Jake fall to his death.

This tantalizing parable resonated with those B-movie westerns, the heroic epic of *The Song of Roland*, Browning's "Childe Roland to the Dark Tower Came," modern malaise. To many readers, it appealed far more strongly

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than King's more famous works. And that appeal didn't seem to flag with volume two, *The Drawing of the Three*, when Roland awakened on a strange shore after a long sleep, lost fingers to "lobstrosities," found strange doors standing on the sand used those doors to pass into the minds of dwellers in different decades of our world, and then drew those dwellers bodily to his own reality. Thus he acquired the company of Eddie, a drug addict who yearned for independence, and Odetta, a legless black civil rights activist with a split personality. Soon thereafter, he killed the man who had once pushed Odetta under a subway train. The same man pushed Jake into New York traffic, but at a later date.

The paradox is both real and painful. Volume three, **The Waste Lands,** gives us a Roland as tormented by warring memories of alternate realities as ever he was by lobstrosities. So is Jake, for he remembers dying, meeting Roland, and dying again, even though he is obviously alive, obviously still in the only life he ever knew, obviously never, never a visitor to any other world, and just as obviously going quite bananas. Now appears a blue rose that seems to say something is seriously awry at the heart of the multiverse and a key—Jake finds it; Eddie carves it—holding which seems to make the mental chaos of warring memories calm down. Knowledge is gained in dreams and premonitions.

Does it sound like fantasy? Up to this point, the series has seemed to fit the science fiction category fairly well. It wasn't the same old galactic empires and superweapon wars, multispecies bars and funny sidekicks. It was something new and fresh and wonderful—something very, very rare in a world where market forces insist that every new book be just like last year's bestseller and Tolkien imitations are like autumn leaves beneath our feet, perhaps something only an established, famous writer, one whose name alone is enough to make a bestseller, could get away with.

Perhaps then it is unfortunate that King is now bending his story in more conventional directions, making the science fiction connection more explicit, bringing in fairly standard furniture, making cute and shallow references to the works of others. There are the giant bear whose nameplate announces that it is a Shardik built by North Central Positronics, Ltd., the ruined city filled with warring, degenerate remnants of once-civilized opponents, radiation mutants, faltering machinery, and a mystic beam that points toward the Dark Tower and along which the world orients itself in roads and vegetation patterns and cloud movements (it is surely no accident that the beam suggests a ley line).

Why is all this so unfortunate? It was the sense of enigma, of strangeness, that so deeply imbued the first two books (especially the first) that made them unique and wonderful. That is lessened, and even though everything shows King's very writerly and original touch, it is all more familiar, less fresh, less wonderful. This is not to say it is not fresh or wonderful at all. It may be less than it seemed for the first two volumes of the series, but it is still one of the few truly original epics to come down the pike since Tolkien. And as everyone knows, King's name on a story almost guarantees compulsive readability.

Buy and enjoy and look forward to the next. Roland and his buddies still have a long way to go to get to the Dark Tower.

Robert L. Forward's latest hard-SF novel, **Martian Rainbow**, shows pre-

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cisely where he is strongest and where he is weakest. His strength is his ideas, the science that makes hard SF what it is. His weakness—well, as I read the book, I kept thinking of comics, where the drawing is crude and events rarely pretend to be the sorts of events that could happen in the real world.

Here's what I mean: The neocommunists are in power in the USSR. East and West are toe to toe in the Baltics. The sovietskis are well entrenched on Mars. The US, under the UN umbrella, mounts an attack to reclaim the Red Planet for the Free World. The victory is virtually bloodless. The conquering general is Alexander Armstrong (descended from *the* Armstrong, of course), who wears a gold-plated space suit and enjoys colossal delusions of grandeur. Leaving his scientist twin brother, Gus, in charge, he returns to Earth. There he immediately meets the man behind a Scientology-like religious scam, and immediately agrees to front the scam as God Incarnate, and takes over the entire world. Presto.

Meanwhile, back on Mars, Gus is showing himself to be a much more reasonable sort, organizing the colonists for independence, collecting all those space-dwellers who don't want to live under an insane theocrat's thumb—literally, since Alexander the Greatest has set up a "Mace of God" kept from pulverizing Earth only by his hand on the controls each Sunday morning—setting up an underground, and discovering strange, modular aliens living in tunnels beneath the ice cap. Eventually, in order to ensure the survival of humans severed from Earth, Gus starts planning to terraform the planet. When he warns the aliens—the Lineups—he discovers that they can and will help. And bingo, Mars is virtually overnight an almost shirtsleeve environment.

I think we can trust Forward on his technical inventions. After all, physics is his field, and the most astonishing rabbits he conjures from his hat have a way of hopping quite realistically. That is, proposals that seem very strange are actually plausible.

But that overnight conquest of Earth, even with the aid of media mavens and computers and sky-eyes that can catch anyone, anywhere in flagrante delicto . . . That insane Alexander . . . That overblown Scientology imitation . . .

You say it's obviously satire? Of course it is. It's not even the first time satire and hard SF have gotten together. Unfortunately, this time the blend does not work well.

One of the favorite games of SF writers is to imagine an alien species and then to tell a story from the point of view of one of its members, sometimes without any human characters at all. Another is dinosaurs, especially since the claim was made some years back that one of the cursorial carnivores had a relatively large brain and might, if given a few more millions of years in which to evolve, have given rise to an intelligent species. Most recently the two games were played together to grandest effect by Harry Harrison in his Eden trilogy.

Now Robert J. Sawyer offers us **Far-Seer,** in which intelligent dinosaurs occupy a tide-locked moon of a gas giant world. These saurians are intensely territorial, functioning socially only in connection with reproduction, the hunt, and religion. The religion centers on the Face of God, first seen generations ago by the Prophet Larsk, who sailed halfway around the world to behold a great round thing in the sky. An older religion, based on the hunt, lingers with a

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prophecy of The One, a hunter of immense prowess who will someday come to lead his people on the greatest hunt of all time.

The tale opens with the introduction of Afsan, the latest—and apparently the brightest—of a series of young apprentices to Tak-Saleed, the palace astrologer. Arriving late for work, he overhears his master talking to an old friend, the sea captain Var-Keenir, and rejecting any use of that new device of lenses in a tube, the far-seer, for examining the moons, planets, and stars in the sky. Afsan thinks the far-seer sounds pretty nifty. Before long, he is finally tackling his rites of passage to adulthood, first a ritual hunt (in which he miraculously slays the largest thunder beast most of his kind have ever seen) and then the pilgrimage to view the Face of God. He sails, of course, with Var-Keenir and gets to use the far-seer himself.

The signs of coming conflict are clear to see. There are the prophecy of The One, Afsan's hunting prowess, the hand-signs made by anti-Larsk demons on a tapestry, repeated by senior hunters impressed by his first kill, and seen on a carven door-panel on Var-Keenir's ship. Then Afsan begins to analyze what he sees through the far-seer, to realize that planets show disks and phases like the moons and thus are spheres, that his own world is a sphere, that the Face of God is not some divine being but another planet around which his world orbits, tidelocked, a moon. Then he notes the rings of rubble around certain other worlds, deduces that when a moon is too close, its primary tidal forces break it asunder, and realizes that since his world is closest to the Face of God and since volcanism and landquakes have been growing more common for generations, then . . . And hey, guys, you know something? There's only one way out of this mess. We've got to learn how to . . .

As soon as you fill in where I put the ellipses, you have to see that it's all a bit much for the religious authorities. They jail Afsan and insist that he recant. He is now as obvious a Galileo figure as you could wish.

Afsan becoming Galileo didn't strike me as silly—I couldn't help but giggle when Var-Keenir turned into Ahab—but the parallel does make *Far-Seer* quite predictable in its basic story line. There are differences, of course. Some are due to the way Sawyer folds in bits of Newton, Roche, and others to make Afsan so remarkable a genius that one wonders why, if the saurians' genetic dice held such a potential throw, no lesser geniuses had ever arisen to leap the species ahead. Some are due to the natures of Afsan's world and biology. But the differences are not enough to keep us from recognizing the overall pattern.

Still, it's a more than worthy effort. Afsan's world and nature feel quite real. The reader gets involved and cheers him on, and many another writer must say to Sawyer just what one saurian says to a superior: "I cast a shadow in your presence."

Which is not to say there are no problems. The greatest may have to do with the "Face" of God and the sort of anthropocentrism a human writer finds it difficult to escape. Consider that since Sawyer's saurians still hunt with tooth and claw, they must retain rather toothy snouts. That is, they don't have round heads or faces and would surely not see a round thing in the sky as a face. An "Egg of God" would seem more likely and would surely serve the story just as well.

Picky, picky.

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* * *

By himself, Spider Robinson built a following with both short stories (many set in Callahan's Bar) and novels such as *Mindkiller*. (*Analog* readers recall him fondly also because he was my predecessor as the Reference Librarian.) Then he and his dancer wife Jeanne wrote the award-winning *Stardance*, in which a dancer performed in space for mysterious aliens. The outcome was the delivery of an asteroid to Earth orbit and the discovery on Titan of a living material that could enter symbiosis with humans and confer extreme longevity, freedom from the needs to eat or breathe, telepathy, and the ability to travel in space without spaceships.

The asteroid became the home of the Starseed Foundation, where humans go to prepare for Symbiosis and become Stardancers. As Stardancers, they then confer numerous boons on their ground-bound kin. Unfortunately, some of those kin are jealous. They hate and fear their benefactors. They want to destroy them even if the destruction dooms all human life on Earth.

This is the context for the sequel, **Starseed.** Morgan McLeod, a dancer in her forties, crippled by arthritis, depressed by the end of all her dreams, realizes that she might be able to dance again in space, as a Stardancer. She signs up with the Starseed Foundation, goes through her training period on Earth, and rides aloft. Even before reaching the asteroid, Top Step, something punctures the ship and kills a steward. It seems an accident, but the Robinsons plant a hint or two to be sure you know it is not. Soon Morgan meets others—Kirra, an Australian Aborigine pursuing the Songlines of her people into space; Ben, a fellow devoted to perceptual distortion; Robert, a Chinese who attracts her powerfully much against her will. She finds that her body does indeed permit her to dance in space, though the conditions of movement are such that she has enormous amounts to unlearn and learn anew. She makes friends. She permits her attraction to Robert to become a love affair.

The asteroid's ventilation system fails. An antisatellite missile nearly makes Top Step uninhabitable. Robert decides it is too dangerous to remain on Top Step and flees back to Earth; when he pressures Morgan to come with him, the affair disintegrates. A new Stardancer—I won't tell you who—explodes and destroys other Stardancers and a mass of fresh Symbiote on its way from Titan. Morgan grows suspicious when it emerges that the explosion could only have happened if the new Stardancer had a bomb inside her, manufactured in situ by nanotechnological devices. She follows Robert to Earth in search of answers to questions, and . . . I hope I haven't said too much. *Starseed* is an absorbing tale, smoothly written, easy to read, and freighted with very human pain and frustration and anguish. You'll enjoy it.

Allen L. Wold's latest, **Lair of the Cyclops,** is a member of the archaeological treasure hunt subgenre of adventure fiction (*Indiana Jones and the . . .*). A satisfying, entertaining puzzle story, it is set in the distant future, when humanity is but one of many species at large in a galaxy with a long history of star-faring civilizations. The galaxy is subdivided into a number of "star nations," one of which, the Federation, is much more peaceful than the rest. In this Federation dwells Rikard Braeth, disowned scion of a powerful, wealthy family; having a knack for

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finding the remains left by vanished races, he lines his pocket with choice antiques and writes scholarly papers he hopes may someday restore him to the good graces of his grandparents. For sidekicks, he has the projective telepath Droagn, last surviving member of the immense, serpentine Ahmear (Rikard found him on a previous adventure), and Grayshard, a being best described as an animate, sentient fungus.

All is going well until Rikard and his friends find an archeologically rich Ahmear ruin buried in deep volcanic ash and lava. As they are leaving with their recordings and samples, they are waylaid by Karyl Toerson and her henchmen. The hijacking is interrupted by the attack of degenerate Ahmears who have dwelt undetected in the ruins for many millennia. Rikard et al., escape with their goodies, one of which suggests that marble cones found on several worlds and hitherto dismissed as natural geological formations are incredibly ancient ruins.

Those cones are the target of the next expedition, and they do indeed prove to be ruins. Unfortunately, Toerson strikes again, and this time she gets away with everything except what Rikard et al., have in their pockets. Fortunately, those few trinkets are enough. Before long, with the help of an uncle, Rikard knows that Toerson has a record for destroying archeological sites to drive up the price of what she has looted. He knows that the cones belonged to a species of molluscoid Cyclopians no history recalls. And in due time he discovers greater ruins, Toerson's link to his family, and the Cyclopians's connection with the Federation's remarkable peacefulness.

What he does not discover is how Toerson was able to dog his heels with such apparent ease. But, considering the resources her family connection implies, that mystery can be ignored. Or perhaps, since Rikard removes only Toerson from the picture in the end, but not the connection, Wold has left the mystery for some future novel. Certainly the book does seem to be part of a series, though the package Warner sent me bore no indication of that.

The book's central message, that the past is worth preserving, is delivered with an awkwardness worthy of the complexities of the real world. Rikard enjoys a strange reputation among academics, who endlessly criticize him for his approach to the past even as they follow his every move with their tongues hanging out, hoping to pick up enough of his crumbs to make their own reputations. They criticize him because looting archeological sites, in our world as in Wold's pages, is an evil exceeded in wickedness only by the wanton destruction of relics. Academics feel that archeology should be done purely, with no eye to profit, certainly with no souvenirs winding up in the archeologist's pockets, even though some of the greatest archeologists of the past have walked off with souvenirs aplenty. Today, very few people try to make the academic and the commercial coexist, and they are almost universally condemned.

Wold is saying that it does not seem entirely unreasonable to permit the existence of free-lance treasure hunters as long as they preserve, as Rikard does, the *information* inherent in sites and relics, and make public what they have found once they have taken their souvenirs. I find it difficult to disagree.

Michael Kandel's latest novel, **Captain Jack Zodiac**, is even more bizarre than his previous works, *Strange Invasion* and *In Between Dragons*. It is, in fact, so bizarre that the reader is likely

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to scratch his, her, or its head and ask, "What the hell is going on here?" Perhaps that is why the book comes from a small press.

What's going on is twofold. Kandel's game is clearly satire. At the same time, he may be trying to see just how strange he can get by violating the rules of the reality we know. As his tale opens, nuclear explosions are lighting up the sky, but the damage is so minimal that Clifford Koussevitzky's neighbor, Bernie Rifkin, doesn't have to don his Power Man persona (gained when his deodorant, his antihistamine, and his beer mysteriously synergized) to set things right. Invading Russian soldiers are mowed down by well-armed commuters when they interfere with the expressway traffic jams. The greenhouse effect and the ozone hole and super pesticides mutate a lawn until it rises up to devour pets and children and pursue its abusing householder across the country. Satanists say their prayers not only backwards but also upside down, standing on their heads. Clifford's son Josh is a space cadet, meaning he buys illegal pills from Captain Jack Zodiac at seven hundred thousand bucks apiece (inflation is terrible!) and teleports to distant worlds to be a hero and fight evil monsters, unless the locals hold him for ransom. His daughter Trish is a mall zombie, a mindless ghost who wanders randomly through the identical malls of six continents. Clifford's girlfriend's late mother throws an ectoplasmic fit when he proposes, even though he promises to convert. Heaven and hell are replaced by Dis, a grey and boring place, complete with post mortem group therapy, in which you can die again, to descend to a greyer and more boring Dis 2 (with post- postmortem therapy); further deaths drop you to Dis 3 and 4 et cetera ad almost infinitum, ending in a room full of computers overseen by a humanoid robot with a most startling tale to tell.

Clifford is the protagonist. He wants to placate his future mother-in-law and therefore uses a black subway token to take the D train to Dis. He wants his kids back and therefore goes to Captain Jack Zodiac for a special pill; when he finds the price too high, he visits a Mom & Pop gun store and . . . Suffice it to say that he achieves all his dreams. In the end, once the robot spells things out and just before Clifford destroys a perfectly good Gibson guitar, Kandel's strange vision of reality even makes sense.

I found Michael Swanwick's **Griffin's Egg** novella less satisfying than much of his other work for two reasons. First, I found the gimmick quite hard to swallow. Second, he did not pursue the implications of that gimmick far enough.

The setting is the Moon. Industry is rampant, and the landscape is rapidly being despoiled by mines and garbage heaps. Earth is on the brink of war. Happy-go-lucky goof-off Gunther Weil learns from a friend that a certain lab is developing a nanotechnology with the potential to rewrite one's thoughts. War begins on Earth. Space station factories are destroyed. The Moon is isolated. And the inhabitants of Gunther's lunar city go mad.

Fortunately, Gunther and a number of others are outside the city at the time. When they return, they promptly see the need to remain in their suits until a portion of the city has been cleansed of whatever agent did the damage. They tackle the immense problem of caring for the mad and maintaining the city as best they can. Gunther's friend reveals more about the nanotechnology of

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thought control, which is clearly responsible for the madness. But it also holds the potential for repairing the damage, as well as for "correcting" personality deficits that make Gunther the goof-off he has always been. Finally humanity can take control of the human brain, free itself of the animal heritage—hierarchy, territoriality, greed, etc.—that leads it again and again into war, and march proudly, arm in arm, into a glorious future. Individuals such as Gunther can also be adjusted to be capable of more rewarding, more stable human relationships. Pairing off becomes a matter of mutual personality adjustment. Paradise. Utopia. No more conflict or discontent. No more dissent. No more free will.

Like Kandel, Swanwick is here committing satire. He is crystallizing something that happens anyway by adding certainty to the process and removing escape clauses. He might even be right in saying that such a thing is possible. If so, God help us all. ■

●When I look at the history of my own field—telecommunications—I can only shake my head in frustration at the inability of technology to either follow or lead society. It reminds me of two clumsy people trying to dance, each attempting to lead with the wrong foot. Let me cite four examples—the Picturephone™, home information systems, facsimile, and cellular telephony. The first two were technologically driven market failures, while the last two were unanticipated market successes.

Robert W. Lucky

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brass tacks

Dear Dr. Schmidt:

I found your October editorial, "Experience Required," quite intriguing. It suggests that our elected representatives would be able to make better use of funds if they had significant experience in making do with little—that is, living in poverty. I think that you have overlooked an important and crucial aspect of the inability of governments to make efficient use of limited funds, the administration of those funds, and have applied your idea to the wrong group.

Although I believe in your proposal, I am convinced that even if every legislator had the credentials and intellect of Lincoln, the impact on governmental efficiency would be small. As you say, elections help, but the idea that less than six hundred legislators and their staffs can have a major impact on the way an independent organization of six million functions, seems a little farfetched to me. On the other hand, if those credentials and intellect were required of administrative officials the results could be spectacular.

Legislators are near geniuses in devising programs and appropriating funds but, typically, they will be nearly powerless to control how the funds are actually used. Little of what happens is dictated by the US Congress, because the budget and its programs are submitted by the administration. Most of what the legislators do amounts to rubber stamping the continuation of programs endorsed by the administrators. Any attempt to "improve" the way these programs function is regarded as rank interference by amateurs. Even when a new program is introduced by legislators, it may be fiercely opposed by administrators, a virtual guarantee of subsequent failure. Programs introduced by the administrators are likely to receive rave reviews by other administrators, gain-

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ing support for years before it becomes obvious that they are abject failures.

Nowhere is this more obvious than in military procurement where the US Congress and the Department of Defense often are at odds concerning major programs. Congress has essentially no control over how funds are actually spent. It is insufficient to argue that the military planners know best. One needs only a modest degree of experience in the system to realize that most programs have a life of their own that has more to do with career advancement than either national security or efficiency. The same is true of the civil sector.

The power of administrators in government should not be underestimated. The president can veto an appropriations bill that contains programs that he does not like, and shut down the federal government until he gets what he wants. It requires imagination to foresee the virtual end of the separation of powers should Congress capitulate to the idea of a line item veto.

Mid-level administrators in government are career bureaucrats, with the emphasis on career. Advancement means administering large programs and having a large organization, not using funds efficiently. It is more the rule than the exception for any program to become top heavy with administrative bureaucracy. Building empires is always more important than getting the job done because attempting to judge how well an administrator has performed is virtually impossible. The failure or poor result of a program is rarely laid at the door of the administration.

Industry is filled with examples illustrating the same idea. General Motors, by its own admission, has tens of thousands of superfluous administrative personnel and an administrative structure that is positively baroque, with at least eleven levels in the chain of command. GM is, supposedly, driven by a profit motive in a competitive environment. How much interest in efficiency can be maintained in a government administration lacking either of these spurs and having no other incentives other than "patriotism."

We have a graphic example in the USSR, in which the "Apparatchiks," that is, bureaucrats, impeded reforms to a marked degree despite legislative attempts to institute changes. Only a determined administrator, such as Yeltsin, or a near revolution had a significant impact, and then only by dismembering the country.

The US administrative bureaucracy is highly entrenched and resistant to change. No matter how well wrought a program may be in concept, it can be destroyed by a hostile administration. By the same token a dedicated administrator with a competent staff can make even a poorly conceived program a success, measured by both accomplishments and efficiency. How to encourage the latter is of some importance if we are not to suffer a continuing erosion in our confidence that government serves a meaningful purpose. This erosion and a concomitant contempt for the rule of law seems to have been encouraged for the past 10 years at the federal level. Now the malaise is present at the state level and is growing at the local level where the quality of services is declining and the real costs are growing. The problem is not a crisis yet, but I am not optimistic that we can avoid the fate of the USSR followed by a slow decline of most of the newly formed confederacies into a kind of modern feudalism.

ROBERT B. MOLER
12003 Bobwhite Drive
Catharpin, VA 22018-1322

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Dear Dr. Schmidt:

The serial, *Barrayar*, is a superb mainline novel. I am confused as to why the author and you made it science fiction. The only "science" item that is basic to the plot is the replicator and the reason for its use. The weapons, transport, etc. could easily be changed to present day technology without any basic change in the story. It is essentially projecting Czarist Russia into the 1990s or a bit later. Is Aral a modified Gorbachev? He couldn't be Yeltsin, as the story is pre-coup.

Even the heroine, Cordelia, could be an enlightened foreigner possibly French, English, or American. Being "off planet" is no more "scientific" than using ray guns instead of pistols.

GEORGE F. KIESEL

St. Louis, MO

The author replies. . . .

Dear Stan,

The "It's not SF!" charge deserves a thoughtful answer, not least because I hesitated for many years to write the book because it did not fit the genre mold, being (on the surface) a political soap opera, and (in its thematic bones) a novel about what it means to be a mother. In a burst of demonic self-confidence I finally said to hell with what anybody else thought, and wrote the story I wanted to tell.

"Barrayar" has nothing to do with current or past events in Russia, I'm afraid, as much as I'd like to take credit for some kind of precognition. It was first outlined in 1983, before anybody had even heard of Gorbachev.

But the most important—vitally important—reason not to make the story some kind of historical is that in a historical novel *the characters cannot affect the outcome of events*. One is stuck with whatever "really" happened, and must either place and constrain one's characters, puppetlike, so that their actions lead only to the real result; or have them try and fail utterly to affect events; or make them "little people," lost to the view of posterity in the cracks. In a word, blech.

I have defined the sort of SF I write as "allegories of change." In that sense, all fiction is psychological allegory, but SF deals especially with those moral dilemmas that arise out of technological change, which is the particular hallmark of our times. The planet Barrayar is "set up" to be an analog of the 20th century, wrenched kicking and screaming fast-forward through its changes. Beta Colony is, perhaps, that "consensus future" we aim towards, and the dance of Beta and Barrayar is the seduction of the present by the future. They are also real (fictional) planets with real people in them—warts, confusion, good intentions, fumbled opportunities, good, evil, and all.

Another reason why it's much too late to redo Barrayar into some kind of mainstream is that it's an integral part of an 8-book series!

LOIS MCMASTER BUJOLD

Dear Stan,

This letter will probably arrive too late to make a difference, but I believe that when we readers vote upon our favorite stories and covers for 1991, there should be a separate category for short short stories.

I always found the "Probability Zero" stories to be quite enjoyable, and they are usually the first thing I'll read in an issue. Unfortunately, when it comes to casting my vote for favorite short stories, I tend to go for the longer "serious" pieces as opposed to these short "light" pieces.

That will change this year, however, as I intend to vote for "Split End" as

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my favorite story of 1991. Was it truly the best? Maybe, maybe not. But it is definitely the best short short that I've read in some time, and I do believe that it should get some representation in the final tally.

Hopefully, if it is too late for this year, you will consider it for 1992. I would like to see more of these pieces, and I'm sure that as the number printed increases, the number—and quality—of these submissions will increase, giving you plenty to choose from.

CHRISTOPHER BURKE
127 Bay 23 Street
Brooklyn, NY 11214

The problem with a separate category for short-shorts is that they're fiendishly difficult to write. Frederic Brown was about the only writer I can remember who managed to come up with a lot *of them that really worked. I see plenty now, but not enough really good ones to warrant a separate voting category. "Among the best three out of four" isn't much of a distinction, which is one reason we don't have a category for serials.*

Dear Mr. Schmidt,

Anent your (November) editorial "Mass," you should realize that your hypothetical computer already exists—in the offices of investment advisers throughout the world, who input an absolutely incredible amount of economic and other statistics into their computers in the hope of predicting the future. The computer exists and the information exists—what is lacking is the software to interpret it. At present the computers give 100% accurate explanations of what has happened, but their view of the future is hazy and contradictory.

As for taking action—this also is already in place. Governmental action through control of money supply and taxes is precisely the broad-spectrum action needed to control the economy within the limits of our present understanding. It is not clear that there are any other levers that can be readily pulled to better effect; all that a proper software program will do is allow us to pull these levers with slightly greater control.

The fine tuning that you seek will not come from the use of sweeping controls—the two are contradictory. It will come from the free interplay of free-market forces.

You should visit a top-flight stock market analyst for a day and watch him struggle to interpret the enormous flow of up-to-the-minute data. He is not living a year or so in the past as your editorial suggests—he is drowning in the present.

DAN E. MAYERS
Switzerland

Dear Dr. Schmidt:

Regarding a socio-economic computer model as a tool for decision making (November editorial "Mass"): the idea certainly merits some study. However, I am concerned with just how such a model would be formulated. While I am at best a dilletante in the computer field, I do have some experience in using them to track a single business.

The difficulty, it seems to me, with trying to model the entire socio-economic system of the US is that there are an almost uncountable variety of elements which impact the movement of the whole. Just trying to get a handle on all of them would be a task requiring a staggering amount of man-hours (man-centuries? man-millenia?). Just the ongoing monitoring necessary to keep the system up-to-date would be incredible.

When trying to boil such a complex

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system down to a small enough size to manipulate, you also run the risk of letting human value judgments creep in. Consider the very different conclusions reached in the First and Second Club of Rome reports, which, of course, were also based on complex computer models. How do we insure that the model we get includes all of the values we desire? And who decides?

Finally, a model limited to national scale is almost certainly no longer appropriate in the interdependent world in which we now live. But if we go to the planetary level, how do we get everyone to agree to act in compatible ways?

It is not my intent to shoot down the whole idea. I'd love to see a detailed study of the concept. But please pardon my reservations.

JOHN K. FOCKLER, JR.

Struthers, OH

The editorials are seldom intended to present Ultimate Definitive Answers, but rather to start people thinking in a particular direction—by asking such related questions as you've raised here!

To the editors:

When there is so much trouble in the world, I think it's more important now than ever to think about the message of hope in science fiction. Gene Roddenberry, the creator of "Star Trek," passed away on October 24, 1991. He, partly inadvertently and partly deliberately, created a series that was one of the first in the field to reach people around the world with this message: Humanity will have a future when all types of people have learned how to get along with each other, and to travel to the stars.

"Star Trek" was first on TV between 1966 and 1969. With all that people have said about the late sixties, there has been very little said about how it felt to be a kid back then, as I was. I remember very clearly—it was far from being all love and flowers. Personally, I found it to be a frightening world: Thousands of people were dying in Vietnam; political and religious figures were being murdered right and left; riots took place in almost every city and university; and no one knew if humanity wasn't going to die in a nuclear war between the US and the USSR if the Vietnam and Middle Eastern situations got worse.

I'm not going to say that watching "Star Trek" singlehandedly helped a lot of kids have faith that there was going to be a future, but at one level or another, in its own way, it did provide a path of reassurance that humanity would not only survive, but do it well. Not as escapism, but as a feeling that we could be proud of ourselves as human beings, that we could do great things as well as terrible ones to each other. This last is a message that even more people could stand to learn or relearn today.

Science fiction has come a long way since "Star Trek," but its message remains the same: People can be great if we will only try. Thank you, Gene Roddenberry, and when people look at and someday take to the stars, we'll be thinking of you.

LEE HOWARD WILEY

Kirkwood, MO ■

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a calendar of analog upcoming events

15-17 May
BLOODSUCKING CONTRAPTION (Ann Arbor area SF conference) at Radisson Hotel, Detroit Metro Airport, Detroit, Mich. Guest of Honor—Nick Pollotta; Fan Guests of Honor—Bob and Ann Passovoy. Registration—$20 at the door. Info: Contraption, Box 2285, Ann Arbor MI 48106. (313) 334-4919.

15-17 May
OASIS V (Northern Florida SF conference) at Ramada Inn, Altamonte Springs, Fla. Guest of Honor—Michael Bishop; Artist Guest of Honor—Holly Bird; Fan Guests of Honor—Ann and Kendall Morris; Special Guest—Andre Norton. Registration—$20 at the door. Info: OASFiS, Box 940992, Maitland FL 32794-0992. (enclose SASE)

5-7 June
AD ASTRA 12 (Toronto area SF conference) at Sheraton Toronto East Hotel & Towers, Scarborough, Ont. Guests of Honour—Katherine Kurtz, Lois McMaster Bujold, jan howard finder. Registration—CDN$25.68/US$22.47 (includes GST) until 26 May; CDN$32 (includes GST) at the door. Info: Ad Astra 12, P.O. Box 7276, Station A, Toronto, ON CANADA M5W 1X9.

5-7 June
New Orleans SF & Fantasy Festival (Louisiana SF conference) at the Clarion, New Orleans, La. Guest of Honor—Stephen R. Donaldson; Artist Guest of Honor—David Cherry. Info: NOSF[3], Box 791089, New Orleans LA 70179-1089. (504) 837-9462.

12-14 June
X-CON 16 (Milwaukee area SF conference) at Marc Plaza, Milwaukee, Wisc. Guest of Honor—Mercedes Lackey; Artist Guest of Honor—Darlene Coltrain; Fan Guest of Honor—Dick Spelman; TM—Larry Dixon. Registration: $20 until 12 May, $25 at the door. Info: X-Con Ltd., Box 7, Milwaukee WI 53201-0007. (enclose SASE)

3-7 September
MAGICON (50th World Science Fiction Convention) at Orange County Civic & Convention Center, Orlando, Fla. Guest of Honor—Jack Vance; Artist Guest of Honor—Vincent Di Fate; Fan Guest of Honor—Walter A. Willis. Registration—$110 adult/$55 child until 15 July 1992; $135 adult/$75 child at the door, Supporting—$25. This is the SF universe's annual get-together. Professionals and readers from all over the world will be in attendance. Talks, panels, films, fancy dress competition—the works. Join now and get to nominate and vote for the Hugo Awards and the John W. Campbell Award for Best New Writer. Info: MagiCon, Box 621992, Orlando FL 32862-1992. (407) 859-8421. UK agent Peter Weston, 72 Beeches Drive, Erdington, Birmingham B24 ODT UK.

29 October-1 November
WORLD FANTASY CONVENTION at Callaway Gardens, Pine Mountain, Ga. Guests—Anne McCaffrey, Michael Bishop, John Farris, Martin H. Greenberg. Limited membership. Registration—$100 in advance; NO at-door memberships. Info: World Fantasy Convention 92, Box 148, Clarkston GA 30021. (include SASE)

You can send me e-mail about your convention—A.LEWIS20 on the GEnie network.

—Anthony Lewis

Items for the Calendar should be sent to the Editorial Offices six months in advance of the event.

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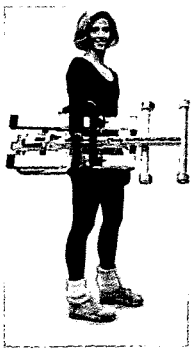

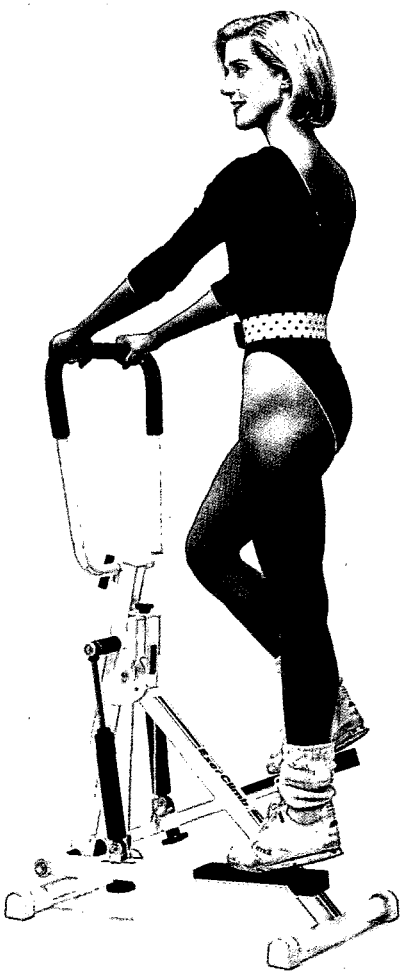

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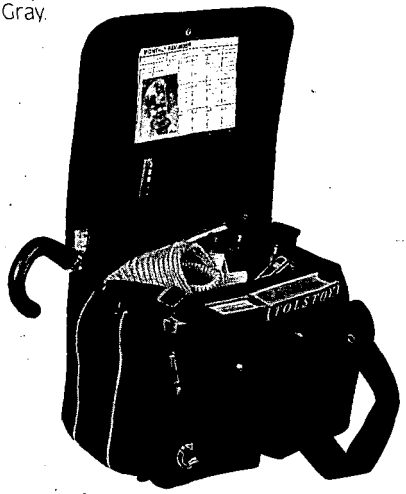

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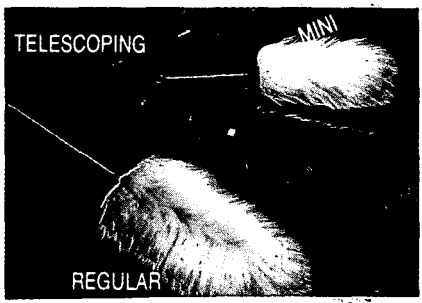

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